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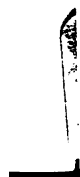
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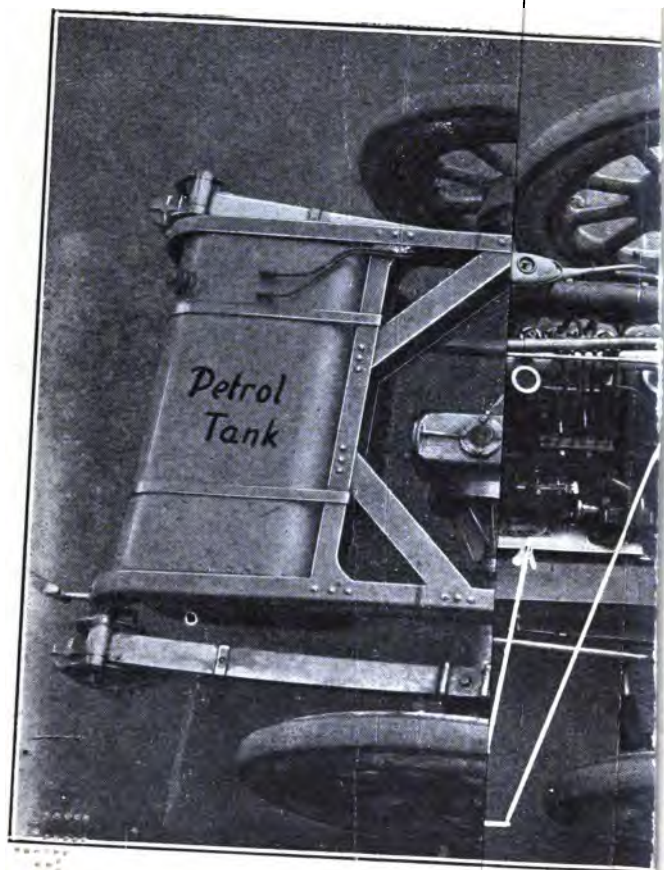
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LONGMANS' TECHNICAL HANDICRAFT SERIES

THE MOTOR CAR



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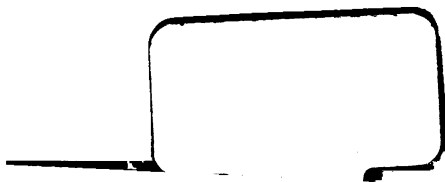
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PREFACE

THE object of the Author, in the pages that follow, has been to take a straight course through the typical modern motor car, beginning at the engine and finishing at the road wheels. The principles underlying the various parts of the car are explained and illustrated by means of simplified diagrams, these being followed by illustrations from drawings and photographs of the actual parts. All variations from main types have been excluded, and as to details no attempt has been made to include the latest in the motor car world. It is hoped by these means to make the elementary principles underlying the construction and working of the modern motor car clear to even the most unmechanical owner.

Chapter I. deals with some elementary ideas regarding the power required to propel a car under varying conditions, and the descriptive work on the motor car proper begins in the next chapter. In order to follow out the scheme of proceeding straight through the car, the descriptions of engines which depart from ordinary poppet valve practice have been placed at the end of the book. This system has proved successful in the courses of popular lectures on "the motor car" given under the auspices of the Royal Automobile Club of South Africa and the South African College, and it has also been found that this simple descriptive course forms an excellent introduction to the more advanced course taken by the engineering students at the College.

A chapter on accumulator and coil ignition has been inserted, even though this type of ignition is almost out of date, for the reason that it is becoming increasingly

common to use coil ignition in conjunction with electric lighting sets.

Very few hints on adjustments or economical running are given. Such do not properly come within the scope of a volume of this nature, and would considerably overload it.

The Author is indebted to various firms for diagrams ; and to his colleague on "Motoring in South Africa," Mr. Thomas Smith, for many valuable hints and for his very thorough reading and correction of proofs.

DUNCAN McMILLAN.

THE SOUTH AFRICAN COLLEGE,
CAPE TOWN,
October, 1914.

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THE MOTOR CAR

CHAPTER I

HORSE POWER AND RATING

Introductory.—A knowledge of the various parts of a motor car and of the principles underlying the construction and working of these parts will help very considerably towards the efficient driving and economical running of this complicated road vehicle. True, many drivers who have little knowledge of what is under the bonnet and below the floor *seem* to be able to get along all right, but this is due to the perfection which has been reached in the design and working of a car. The expert knows that a driver of this type is running a car at a considerably greater cost than necessary; and in spite of the fool-proof nature of the mechanism and controls, sooner or later a large repair bill will be incurred, and possibly a bad accident may happen. Though roadside stops, due to something going wrong with the mechanism, are much less common than they used to be, occasionally something does go wrong which makes it impossible to proceed. Usually the remedy is a simple one, but the driver who knows nothing of his car cannot make even a simple adjustment, and has to wait till some good Samaritan comes along and helps him, or until an expert mechanic arrives from the nearest garage. Sometimes he has to be towed home, and this is a bitter experience. There is not the slightest doubt that running costs can be considerably reduced if an intelligent interest is taken in the mechanism of a car and the necessary adjustments and small repairs executed periodically. It is not advocated here that every driver should be an expert

mechanic, and do all the repairs and adjustments to his car, but the ordinary driver should know enough to repair an ignition wire, find out if his plugs are foul, see that all nuts are tight, keep his tyres in good order, and make similar simple adjustments. Above all he should have enough knowledge to enable him to know when to leave the car alone and take it to the garage for repairs. The largest repair bills are incurred through the driver tinkering up the car himself and running it long after a skilled man would have had the car looked into at the repairer's.

The Writer's Aim.—There are quite a number of handbooks dealing with the motor car, and most of these are good. Their greatest disadvantage lies in the fact that there is far too much in them, and the non-technical reader has little chance to pick out the main and important points from the mass of detail and variations given. In the work which follows the writer's aim will be to explain general principles and their application, and no attempt will be made to go into refinements or discuss the relative advantages of the latest in the motor world. For the sake of illustration of principles it may even be necessary to take for illustration purposes some design which has long been discarded, but which is simpler than the more efficient but more complicated present-day design. If the reader can gain access to a car and examine the various parts as they are described, it will be of great advantage to him.

Horse Power.—Before commencing the work on the motor car proper, it would be well to understand how the power in a car varies. One hears of 8 horse power cars, 10-12 h.p. cars, 12-16, 16-20, 25-30, etc., cars. Everyone understands that a 25-30 car is a larger and heavier car than a 10-12, but few understand how a car can be both a 10 h.p. and a 12 h.p. car at the same time, and there are not many outside the engineering profession who know what "horse power" actually means. It seems strange to the layman that any vehicle should require the power of 25 horses to propel it, even though it travels at high speeds. What is meant by "horse power"? The story goes that the term was coined by James Watt, the inventor of the steam engine, in order to give the buyers of his engines some idea of what amount of work the engines could do.

His engines in most cases were used to perform work that had previously been done by horses harnessed up to a gin, pulling round in a ring, and Watt had to guarantee that his engines would do the same work as so many horses. Hence the term "horse power." Nowadays it is used simply as a unit of power, without reference to the work of horses. It will be interesting, however, to see the relation between horses and horse power in the case of the motor car, as in this case they can to some extent be compared. The non-technical reader will have serious doubts as to the capabilities of even a modern 3 h.p. motor cycle, for example, in a tug-of-war contest against a single horse. He would wager on the horse, and in an actual pull for a short time he would win. A horse can, for a short time, probably develop 5 to 8 h.p., and can develop 3 to 4 h.p. for periods as long as half an hour. But when it comes to a period of many hours the work done by three horses would be less than the work done by a 3 h.p. engine. The whole point is that the engine does not tire out, whilst the horse requires long periods for rest and for feeding. Thus the work that can be got out of a 3 h.p. engine, when a long period is considered, is greater than the work that can be done by three horses in the same period.

The great disadvantage of the engine lies in the fact that when doing its best it cannot for even a very short time give out much more than 3 h.p., whilst three horses could work at the rate of 15 to 20 h.p. for a short time. In the motor car, then, we require to have an engine which will be large enough to do the greatest work that will ever be required from it when climbing a steep hill or battling at high speed against a gale of wind. When running along a level road at about twenty miles per hour the engine in a medium-sized car is only developing 4 or 5 h.p. A man in good health can, for one or two minutes, work at the rate of slightly over 1 h.p.; but for long periods a man can only develop 1-10th to 1-8th h.p.

Work.—"Horse power" has still to be defined; and the engineer's definition of h.p. is that for every h.p. 33,000 ft.-lbs. of work require to be done in one minute. Thus a 3 h.p. engine would require to be able to do $3 \times 33,000$ ft.-lbs. of work in every minute during which it was

working. This definition of h.p. involves work, so work will have to be defined. When a resistance of one pound is *overcome* through a distance of one foot, one foot-pound (ft.-lb.) of work is said to be done. Note that the resistance must be overcome—that is, there must be movement. Examples: A motor car weighing one and a half tons requires a pull of about 60 lbs. for every ton weight of car to move it on a good level road. What amount of work will be done in one minute if the car is travelling at the rate of 1320 feet per minute (15 miles per hour)? The resistance to movement here is $1\frac{1}{2} \times 60 = 90$ lbs.; and this resistance is overcome—that is, the car is moved a distance of $\frac{1}{4}$ mile = 1320 feet in one minute. The work done per minute then is $90 \text{ lbs.} \times 1320 \text{ ft.} = 118,800 \text{ ft. lbs. per minute.}$ This means that the engine—provided that none of the work was lost in friction—would require to develop $\frac{118,800}{33,000}$ or 3.6 h.p. It should be noted that though the whole $1\frac{1}{2}$ tons is moved, the pull required to move it—that is, the resistance overcome—is only 90 lbs.

Power for Hills.—When a car is travelling up a hill not only do we have the road resistances which are the same

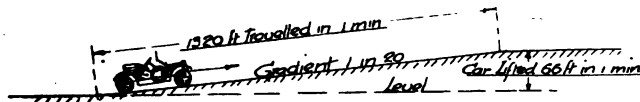


FIG. 1.

as on the level, but the whole car has to be lifted through a height depending on the speed of the car and the steepness of the hill. Take a hill whose gradient is 1 in 20, then at 15 miles an hour the car would travel 1320 ft. along the road and it would require to be lifted $\frac{1}{20} \times 1320 = 66$ ft. That is, as well as overcoming a resistance of 90 lbs. parallel to the road a resistance equal to the weight of the car ($1\frac{1}{2} \times 2240 = 3360$ lbs.) would require to be overcome in the shape of a vertical lift of 66 ft. per minute. Horse power required for this = $\frac{3360 \times 66}{33,000} = 6.72$ h.p. These results will be utilised later when the question of how the work done by an engine in a car is made use of in propelling the car.

Rating.—Knowing what is meant by “horse power,” the various kinds of h.p. may be noted. There are three,

which will be considered: (1) Indicated horse power, or I.H.P.; (2) Brake horse power, or B.H.P.; (3) Nominal horse power, or Rating. I.H.P. is the power developed in the cylinders of the engines. The whole of this is not available for driving the car, as some of it is used up in overcoming the friction of all the various shafts and bearings, gearing, etc., in the car, and in transmitting the power from the engine at the front through the mechanism to the driving wheels at the back of the car. The b.h.p., or useful h.p., in a motor car means the h.p. given out at the driving wheels, and the whole of this is available for driving the car. The nominal horse power or rating may be the maker's method of stating the size of the car, or it may be the Government's size for taxing the car. In both these cases the rating can only be taken as approximate. For example: When a maker produces a 12-15 car, say, it is usually taken to mean that the car can at any time develop 12 b.h.p., and under certain favourable conditions, such as increasing the speed of the engine and using more petrol, the b.h.p. available for propelling the car may go up to 15, or even a little more, for a short time. The Government Rating does not usually give an accurate estimate of the power available, as makers design their engines to some extent to make this figure low. It is becoming increasingly common for makers to design their engines so that they just come under a certain rating. For example, there are 11'9 h.p. cars and 15'9 h.p. cars. This does not mean that the maker can estimate the h.p. developed so accurately that it requires fractions of a h.p. to state it, but that these cars are just under the 12 h.p. and the 16 h.p. ratings respectively.

How the Power is spent.—The power available at the back wheels is used up in the following ways: (a) In supplying the force required to move the car; or, as it is called, the tractive force. This varies from 8 lbs. per ton weight on a railway to 200 lbs. per ton on bad and muddy roads. In deep sand and mire it may even be greater than this. About 1905 the committee of the Royal Automobile Club estimated this road resistance at 60 lbs. per ton weight on good roads, so that for purposes of calculation it may be taken at from 40 to 100 lbs. per ton, depending on the state

of the road. (b) On the level the only other important resistance is the wind resistance. When a car travels at the rate of 20 miles per hour through still air it is meeting the equivalent of a breeze blowing at 20 m.p.h. ; and when travelling at this rate, and the wind is actually blowing in the opposite direction at the same rate, the car is overcoming a resistance due to a breeze of 40 m.p.h. It is difficult to

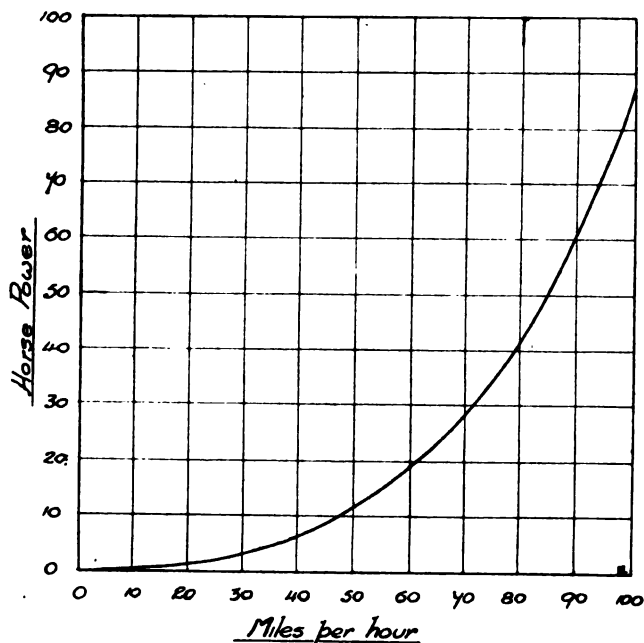


FIG. 2.

calculate the power required to overcome this resistance, for the resistance does not vary directly with the speed but is much greater at higher speeds. The power required to overcome the wind resistance at 40 m.p.h. is more than five times that required at 20 m.p.h., and if a car travels at 80 m.p.h. then the power required to overcome the wind resistance will be about 20 to 30 times that required at 20 m.p.h. The following curve is from Strickland, and has

been compiled from data obtained by Colonel Crompton in towing vehicles along the road. It assumes that the area of a car facing the wind is about 12 sq. ft. A small car would have less than this, but a large car, or a covered car, would have a larger area facing the wind. (c) When travelling up a hill power proportional to the height the car is lifted per minute is required—that is, proportional to the steepness of the hill. This has already been explained.

Some Figures.—The power required to drive the car on the level at any speed is spent in overcoming ($a+b$), that is (tractive force + wind resistance). The power required for the tractive force can be calculated as shown, and the power required for the wind resistance can be taken from the curve. If at the same time the car is climbing a hill the power required will be ($a+b+c$) (tractive force + wind resistance + power required to lift the car up the hill). In order to illustrate this, the power required for a medium-sized car, say of 16–20 h.p., under varying conditions, is given. Take the car running at 15, 30, and 45 miles per hour on the level. When there is no wind blowing, the power required is approximately as follows:—

Due to	Weight of Car.	Miles per Hour.	H.P. required.	Total Approximate h.p.
Traction	1½ tons.	15	3·6	} 4·6
Wind	1½ „	15	less than 1	
Traction	1½ „	30	7·2	} 10·2
Wind	1½ „	30	about 3	
Traction	1½ „	45	10·8	} 19·8
Wind	1½ „	45	about 9	

Taking the same speeds when ascending a hill of 1 in 20 (a very ordinary hill), then the approximate h.p. will be—

$$\text{At 15 m.p.h.} = 3·6 + 1 + 6·72 = 11·32$$

$$\text{At 30 m.p.h.} = 7·2 + 3 + 13·44 = 23·64$$

$$\text{At 45 m.p.h.} = 10·8 + 9 + 20·16 = 39·96$$

In all the above cases the h.p. given out at the back wheels, or the b.h.p., is meant. The h.p. at the engine, or the i.h.p., will be about one-quarter to one-third more. The above figures are not meant to be rigidly accurate: cars

vary so much, and our knowledge of what is actually happening is so comparatively small, that only approximate figures can be given. But the figures show the relations between the powers required at various speeds with fair accuracy. They also show why a high-powered car is required if a high average speed is to be maintained.

CHAPTER II

THE GENERAL ARRANGEMENT OF A CAR

To the lay mind a motor car seems a very complicated machine. Doubtless this in many cases keeps the prospective motorist from buying a car, especially if for financial reasons it would be necessary for him to look after it himself. But while it is true that the number of separate parts in a complete car is great, and the possibilities of one or more of these going wrong seem endless, the fact remains that with ordinary care they seldom do go wrong, and cars very often run some thousands of miles before any attention except the necessary cleaning and oiling is required. It will assist the beginner if, before explaining in detail the construction and working of the mechanism of a motor car, the various parts are considered in relation to the whole car.

Comparisons.—Comparisons with the horse-drawn vehicle will prove helpful. In this there is a fairly intelligent motor, namely, the horse, which under the guidance of the driver can be made to give many useful variations. A horse can go quickly or slowly; it can be made to go backwards; a slight indication by means of the reins will turn it to the right or to the left; and when required it can be made to act as a brake and so retard the speed of the vehicle. On a horse-drawn vehicle there is also a brake on the wheels which is controlled by the driver. These wheels are simply rollers rolling on the road, the axles being rigidly fixed to the body of the carriage. The motor car must be able to do all the horse-drawn vehicle can do, and in its case some special piece of mechanism must be provided for each operation performed by the horse. One great difference between these two kinds of locomotion is that in one case the power is external to the vehicle itself,

the horse pulling the carriage just as a locomotive pulls a train, whereas in the case of the motor car the whole car is pushed along by the grip of the back wheels on the road, the power being transmitted from the engine at the front to the axle at the back. The road wheels are keyed to this axle and go round with it.

Speed Ratios.—The pulling power in the car is supplied by the engine; but in order that full power may be developed at the engine, it must always run at about the same speed. The car, however, must run at varying speeds. For example: when going up a hill the speed of the car must be reduced, whilst the power of the engine requires to be at its greatest, and therefore the speed of the engine must be a maximum. This variation of speed of the road wheels while the engine runs at constant speed is arranged for in the gear box, where different-toothed wheels are engaged for various speeds. The gear box also gives a reverse drive and a neutral position—that is, a position where the wheels are not in gear. The gear box is usually placed between the engine and the back wheels, in the middle of the car, and the gears are actuated by means of a lever at the driver's side.

Fuel.—The fuel supplied to the engine is petrol, and this must be prepared before giving it to the engine—that is, it must be converted into atomised petrol or petrol mist. A large quantity of air must also be mixed with this petrol mist. The mechanism which atomises the liquid petrol and mixes it with air is called the carburettor—this being placed at one side of the engine.

Ignition.—To ignite this mixture of petrol gas and air an electric spark is used. The electricity required to give this spark is either stored in accumulators or is made as required by a machine called a magneto. The magneto is generally to be found close to the engine, and if accumulators are used they are usually carried below the seat of the car or in a box on the running board.

Clutch.—In order that the engine may revolve without any part of the mechanism between it and the road wheels being in motion, and to provide a rapid means of disconnecting the engine and the back or driving road wheels for

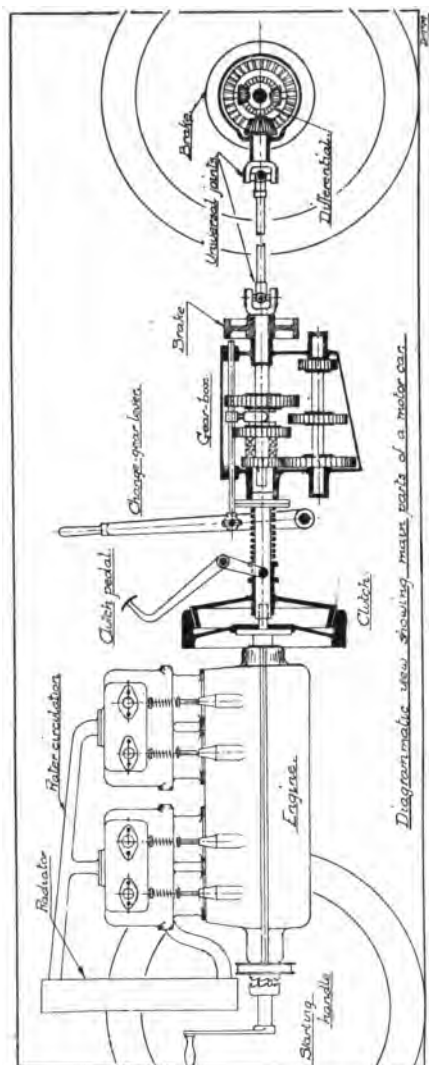


FIG. 4.

gear-changing purposes, it is necessary to provide a clutch. The clutch is immediately behind the engine and is actuated by a foot lever. A glance at the frontispiece and diagram Fig. 4 will show the relative positions of engine, clutch and gear box. Behind the gear box, and carrying the power to the back wheels, is the propeller shaft. To allow for the relative springing up and down of the back axle and the rest of the car this shaft has to be made in such a way that it can still drive though out of line. This is provided for by means of universal joints at each end. The drive from the engine through the car lengthwise is now converted by means of bevel wheels, or worm and worm wheel, to a crosswise rotation at the back axle. The road wheels, being fixed to each end of the back axle, go round with it, and so drive the car forward.

Differential, Brakes, etc.—In the centre of this axle there is an arrangement called the differential, or balance gear, which, while still connecting the two road wheels, permits of their rotating at different speeds, and so allows the wheels to turn a corner without slipping. There are two brakes on the car. One acts directly on the road wheels and is usually worked by a lever at the driver's side; the other acts on the propeller shaft and is controlled by the driver's foot, though cars of American make very often have both brakes acting directly on the back wheels. In order to steer the car a steering wheel is used, the bottom of its spindle being connected to the front wheels by means of levers. A radiator, the function of which is to cool the water coming from the engine jackets, is usually fitted in front of the engine. If the engine cylinders were not surrounded by cooling water they would become red hot and the engine would not work. Other necessary parts of a car are: road wheels, frame, torque and radius rods, springs, silencer, oil and petrol tanks, starting handle.

Tyres.—So that the vibration and noise due to travelling over the roads at high speeds may be reduced, and also to save the mechanism and engine from vibration, pneumatic tyres are used. The wear on tyres is, with the exception of depreciation, the cause of the greatest expense in running a car. Intelligent handling, careful adjustment of the wheels and correct pressures will save the motorist many

THE GENERAL ARRANGEMENT OF A CAR 13

pounds per annum in the running of a car. It is an accepted fact that the careful driver who uses his brakes as little as possible, keeps the pressures correct, and in general looks well after his tyres, will get one and a half times the mileage out of a tyre in comparison with that obtained by a careless driver.

CHAPTER III

THE ENGINE

Engines.—The engine is the most important item in the composition of a car, and will be considered first. Together with its attendant parts, it is also the most complicated portion of the car; for as well as the engine proper there are, in intimate relation to it, the carburettor, the ignition apparatus, the water- and oil-pumps, and the radiator. Engines using gas developed from petrol predominate; and of petrol engines more than ninety-five per cent. work on the Otto Cycle.

The Otto Cycle.—The function of the engine is to develop power. As we have seen, power is the rate of doing work; and work is resistance overcome multiplied by distance. The work done in an engine during one stroke is the average pressure (P) multiplied by (D) the distance the piston is moved. The work done per minute is therefore $P \times D \times \text{number of working strokes per minute}$. In an engine working on the Otto Cycle, in order to get one working stroke three other strokes are required. It would be better to call this cycle the four-stroke cycle. The four strokes are as follows:—

First Stroke.—Suppose the piston to be at the inner end of its stroke and a charge of gas and air in the cylinder: the charge is ignited by a sparking plug and the pressure in the space P (see Fig. 5) rises considerably and drives the piston out, thus doing work. It should be noted that this to-and-fro or reciprocating motion of the piston is not a convenient one, and in order to make use of the mechanical energy generated this motion has to be converted into a rotary one. This is done by means of the connecting rod and crank. This stroke is called the working or explosion stroke.

Second Stroke.—At the end of the working stroke the space behind the piston is filled with burnt or inert gas. This has to be expelled, and to do this the second stroke in this cycle is utilised. In this case, instead of the piston doing work on the crank shaft, the crank shaft has to give work back to the engine and push the exhaust gases out through the exhaust valve. This stroke is called the exhaust stroke.

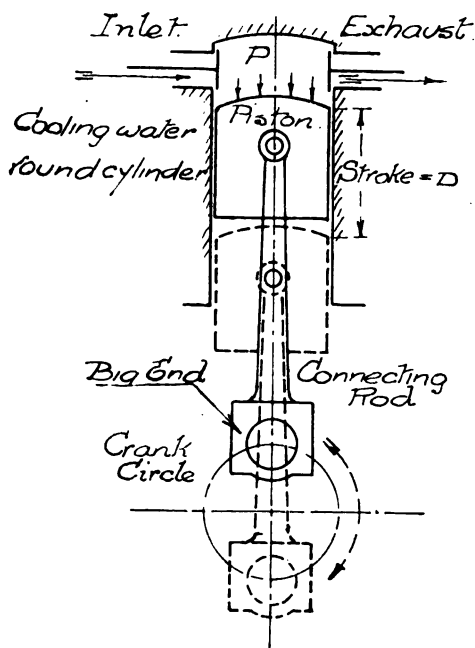


FIG. 5.

Third Stroke.—The exhaust valve closes at the end of the second stroke; the inlet valve opens; and the piston is pulled out by the crank, thus causing a partial vacuum in the space behind the piston. This causes an inflow of petrol (in the form of a very fine spray) and air into the cylinder, which later will be burned to give another working stroke. This third stroke in the cycle is called the suction stroke.

Fourth Stroke.—When the piston has reached the farthest-out position the inlet valve is closed, and the crank again drives the piston back. As the piston moves back the combined petrol spray and air is compressed into smaller volume under the increased pressure. Whilst it is not absolutely necessary to compress the gas before burning it, the engine gives more power and its efficiency is greatly increased (as we shall see later) by means of this compression. This fourth stroke in the cycle is called the compression stroke. Again the crank has to give work back to the engine, and in this case the work done is of considerable volume. The pressure on the piston tending to stop the engine at the end of this stroke may be as much as 80 pounds on the square inch, though it is usually less than this, or a total pressure of 1000 pounds on a piston four inches (100 millimetres approximately) in diameter.

The Complete Cycle.—The four strokes in the cycle are : (1) Working Stroke ; (2) Exhaust Stroke ; (3) Suction Stroke ; (4) Compression Stroke.

In all internal-combustion engines these four operations are essential, no matter what the cycle is. In the two-stroke cycle all four are performed in two strokes or one revolution. Fig. 5 shows diagrammatically the general cylinder arrangement of a motor car engine. The main parts are indicated on the drawing. It should be noted that the valves open into the cylinder, so that the pressure due to explosion or compression tends to close the valves still more effectively.

Valves.—Fig. 6 shows a valve and the section of the valve casing. The up-and-down movement of the valve is controlled by the projecting part on the cam shaft. In order that the valve should not stick in its guide as the result of friction, and also to ensure its closing quickly, a fairly strong spring is provided. The constant wear on the end of the valve stem and on the tappet rod at A is taken up by means of having the length of the tappet adjustable. The valve cap is large enough to allow the head of the valve to go through. Two each of such valves, rods, cams, springs, etc., are required for each cylinder—one set for the inlet as shown, and a similar set for the exhaust.

Timing.—The cam shaft (Figs. 8 and 9) rotates at half the speed of the crank shaft (Figs. 7 and 9), as each valve

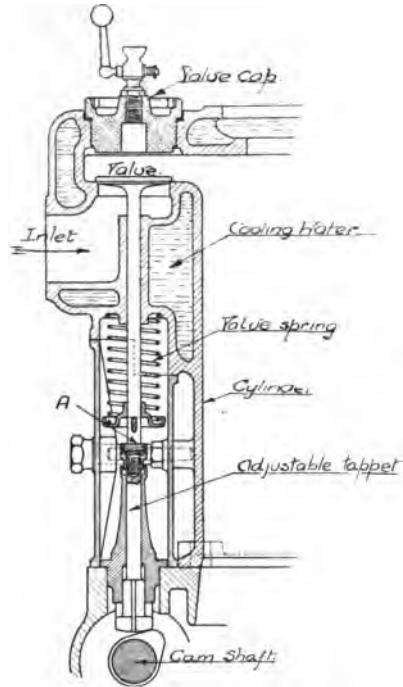
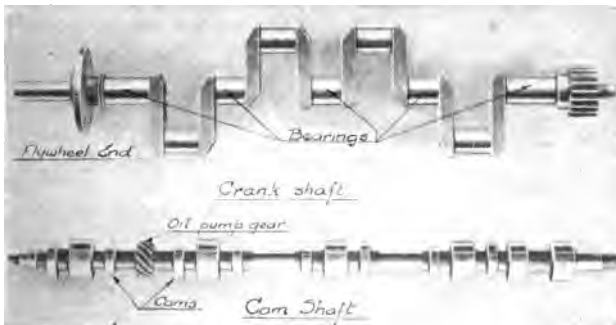


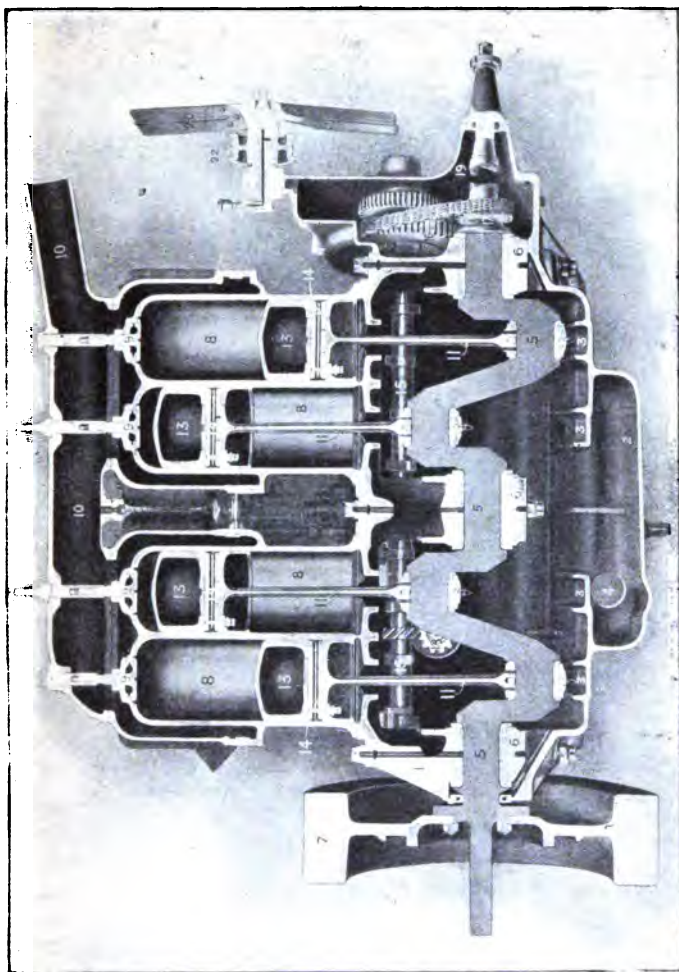
FIG. 6.



FIGS. 7 and 8.—Crank and Cam Shafts from a Sunbeam Car.

only opens once in every two revolutions of the engine. This is arranged for by having a small wheel on the end of the crank shaft, connected—either by direct gearing or by means of gear chain—to a wheel of twice the diameter on the cam shaft. These wheels are known as the timing wheels, because, by altering their relative positions, the times at which the various openings and closings of the valves occur can be varied (see (16) and (17) in Fig. 9). Alongside wheel (16) there is another wheel, which is used for driving the cooling-water pump and the magneto, and which is geared up to the common shaft for these by means of a chain also, as in the case of the cam shaft. (The positions of the water pump and the magneto are shown in Fig. 10.) On the same shaft as this wheel, but outside the casing, there is a belt pulley. This is for the belt which drives the fan placed behind the radiator (see Fig. 10).

Other Details.—Taking the various details shown in Fig. 9: (1) shows the crank case, in which are cast the various main bearings (6) for the crank shaft. At the bottom of the crank case a well or sump (2) is cast as a storage receptacle for the oil used by the engine when running. From this the oil is pumped to the main bearings (6) and to the oil troughs (3). On the big ends of the connecting rods scoops are fixed, which dip into the troughs and thus lubricate the connecting-rod bearings (12), besides splashing a sufficient quantity of oil over the walls of the cylinders (8) to lubricate the pistons and the gudgeon pins (14). Outside the crank case, at the back end, is the flywheel (7), and an arrangement is shown whereby any oil which may leak through between the bearings is stopped and returned to the crank case. While the engine is working there is a continuous flow of cooling water round the cylinders and upwards to the outlet pipe (10), through which it is led to the radiator. The water is again cooled in the radiator by means of cold air kept in circulation by the action of the fan and the speed of the car, and is then pumped back to the cylinders, and so on. The gudgeon pin (14) across the internal diameter of the piston is connected to the crank shaft (5) by means of the connecting rod (11). The ends of the connecting rod are called the gudgeon end and the big end. The pistons (13) are long,



1. Crank case.
2. Oil Base.
3. Oil Troughs for Connecting Rods.
4. Oil Drain.
5. Crank shaft.
6. Crank shaft Bearing Blocks.
7. Flywheel.
8. Cylinders.
9. Cylinder Blocks.
10. Water Outlet Pipe.
11. Connecting-rods
12. Connecting-rod Bearings.
13. Pistons.
14. Gudgeon Pins.
15. Cam shaft.
16. Cam-shaft Chain Wheel.
17. Crank-shaft Chain Wheel.
18. Oil and Water Pump Driving Wheel
19. Engine Chain Cover.
20. Fan Blades.
21. Fan Spindle.
22. Fan Centre and Pulley.

FIG. 9.—Sectional View of 16-20 Wolseley Engine.

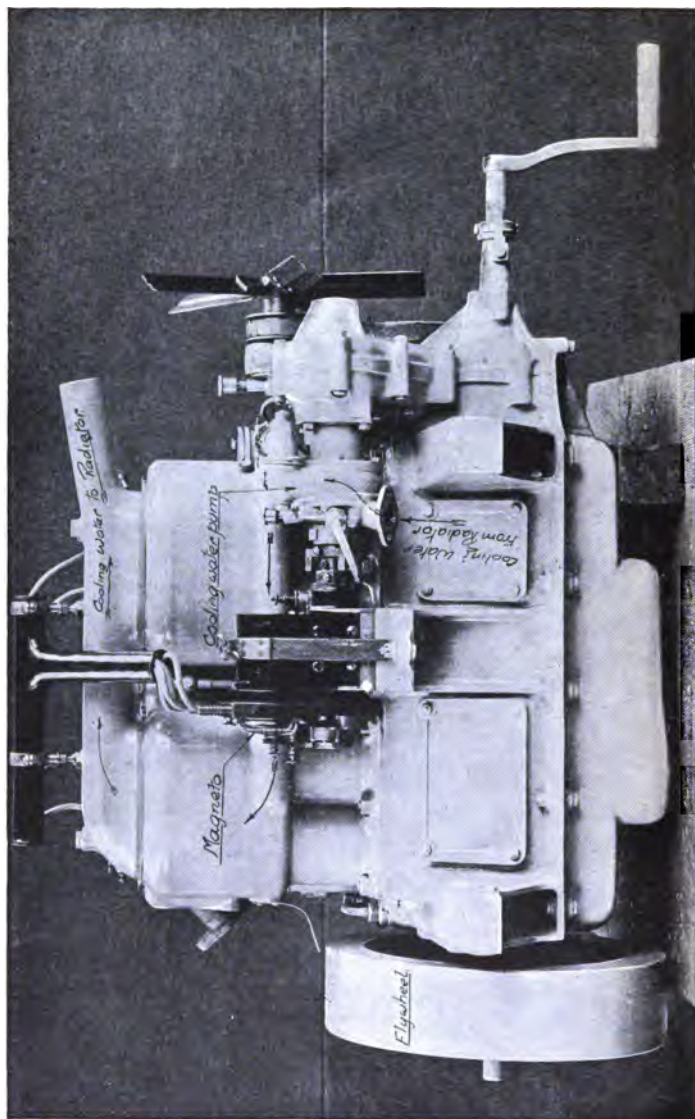


FIG. 10.—Outside View of 16-20 Wolseley Engine.

hollow, cylindrical sliding pieces, and have usually three spring rings (in grooves) which press outwards against the cylinder walls, and so prevent the pressure on the top of the piston escaping down between the piston and cylinder. These rings also prevent too much lubricating oil working up past the pistons to the combustion ends of the cylinders. Piston rings are necessary because the piston cannot be made to exactly fit the cylinder, but must be somewhat smaller in diameter. The reason is that while the engine

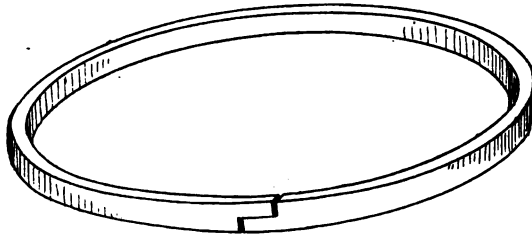


FIG. 11.—Piston Ring.

is working the piston is at a much higher temperature than the cylinder, with the result that it expands to a greater extent ; and if this difference in expansion was not allowed for the piston would stick. Fig. 11 shows one type of piston ring. The cam shaft (15), on which there are eight cams—two for each cylinder—has already been mentioned ; also the chain wheels (16) and (17). On the cam shaft the wheel for driving oil and water pumps is shown at (18). The pumps themselves will be dealt with later. The other parts (19), (20), (21) show the fan and its connections.

CHAPTER IV

THE ENGINE (*continued*)

Pistons and Crank Positions.—In order to study the action of the valves and the timing of the spark it is necessary to have some method of stating the position of the piston in its stroke, or the position of the crank in its circle, when the valves open and close, and when the spark takes place. These events occur near either end of the stroke: it is difficult to find the exact position of the piston in this region of its travel, because a small movement of the piston means a comparatively large angle of turning of the crank. Again, as the crank is for all practical purposes turning with uniform speed, the angles described by the crank are proportional to time. For example: if the spark which fires the charge occurs 20 degrees before the crank is in its vertical position—that is, its top dead-centre position—the time available for the explosion to take place will be exactly twice what it would be if the spark took place 10 degrees before dead-centre position, the engine running at the same speed. For this reason, and because of the difficulty of getting the piston in the exact position required, it is usual to state the position occupied by the crank when any action occurs, rather than the position of the piston in its stroke.

Illustrating this it is usual to say that the exhaust valve opens 50 degrees early, meaning that the exhaust valve opens 50 degrees before the crank reaches dead-centre position. It should also be noted that when the angular position of the crank is given it fixes the time at which the event takes place exactly, irrespective of the length of the stroke. The table and diagram in Fig. 12 give a comparison of the angular positions of the crank and the percentage of the stroke accomplished by the piston at these

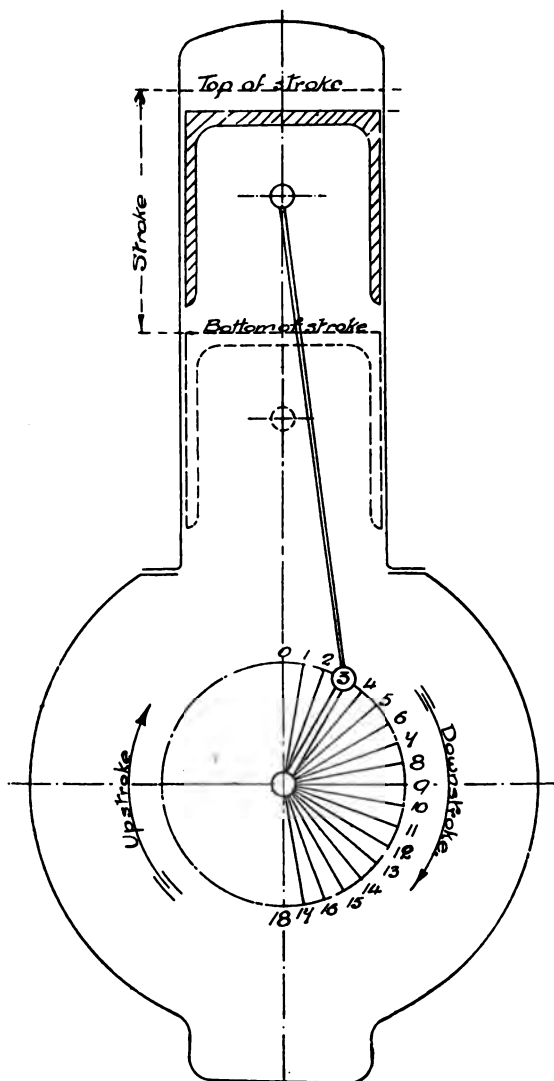


FIG. 12.

different angular positions for both the downward and upward strokes of the piston. It should be noted that, due to the angularity of the connecting rod, the piston positions on the upward stroke differ slightly from those on the downward stroke for the corresponding angles of turning of the crank from dead-centre positions.

TABLE GIVING POSITION OF PISTON IN ITS STROKE FOR ANY CRANK ANGLE.

Position of Crank Angle from Dead Centre.	Distance from top of stroke—down stroke. Millimetres or per cent.	Distance from bottom of stroke—up-stroke. Millimetres or per cent.
0 degrees.	0·0	0·0
10 "	1·0	0·5
20 "	4·0	2·5
30 "	8·5	5·25
40 "	14·5	9·0
50 "	22·0	14·0
60 "	30·0	20·2
70 "	39·0	28·5
80 "	47·5	37·5
90 "	56·5	43·5
100 "	62·8	52·5
110 "	71·5	61·0
120 "	79·8	70·0
130 "	86·0	78·0
140 "	91·0	85·5
150 "	94·75	91·5
160 "	97·5	96·0
170 "	99·5	99·0
180 "	100·0	100·0

[The figures given are for an engine with a stroke of 100 mm. Should the stroke be longer or shorter than this, the figures can be treated as a percentage of stroke. In Fig. 12 the crank is shown 30° from dead-centre, and the corresponding position of the piston is 8·5 mm. from the top of stroke. Similarly any other angle may be taken.]

Valve Timing.—In the description of the Otto Cycle it was stated that each of the four actions—working, exhaust, suction and compression—occupied one stroke. In theory this statement is quite correct, but in practice the time occupied by each action is either a little less or a little more than one stroke. Again, in theory the valves

open and close and the spark takes place at the end of a stroke ; in practice the valves do not open and close at the end of the stroke, and the spark takes place considerably before the end of the compression stroke. Whilst the position of opening and closing of valves varies to some extent in different makes of cars, those given below strike a fair average.

✓ TABLE GIVING POSITIONS FOR OPENING AND CLOSING OF INLET AND EXHAUST VALVES FOR VARIOUS MAKES OF CARS.

Make of Car.	Inlet Valve.		Exhaust Valve.	
	Opens.	Closes.	Opens.	Closes.
Albion	14° late	30° late	44° early	16° late
Arrol-Johnston ..	16° late	36° late	53° early	13° late
Deasy	20° late	35° late	55° early	15° late
Humber	13° late	37° late	47° early	13° late
Star	12° late	17° late	47° early	9° late
Wolseley	11° late	19° late	38° early	7° late

Inlet Valve.—The inlet valve usually opens from 5 to 20 degrees late, that is after the crank has reached the vertical position where theoretically it should open. There are two reasons for this : firstly, it must not be open (for ordinary running) before the exhaust valve closes, and the exhaust valve closes from 0 to 15 degrees late ; secondly, if the valve opens somewhat late the suction on the jet in the carburettor is more sudden and a larger quantity of petrol is drawn into the cylinder. This valve closes from 15 to 35 degrees late. All actions take a certain amount of time to develop—that is, the desired result usually lags behind the action which causes it. So that while theoretically the suction action on the carburettor stops when the piston reaches the end of the stroke, practically it is felt for a short time after that event. In order to get the cylinder as full as possible of petrol and air the valve is made to close late. A and B (Fig. 13) show the approximate positions of the crank when the inlet valve opens and closes, A₁ and B₁ giving the positions of the piston.

Exhaust Valve.—The exhaust valve opens 35 to 55 degrees early in order that the cylinder full of burnt-out or inert gas may be somewhat cleared out before the piston is on the return stroke. In a motor car engine the exhaust passage from the cylinder is not in direct communication with the outer air; and the gases have to make their way along a pipe of considerable length, then they have to

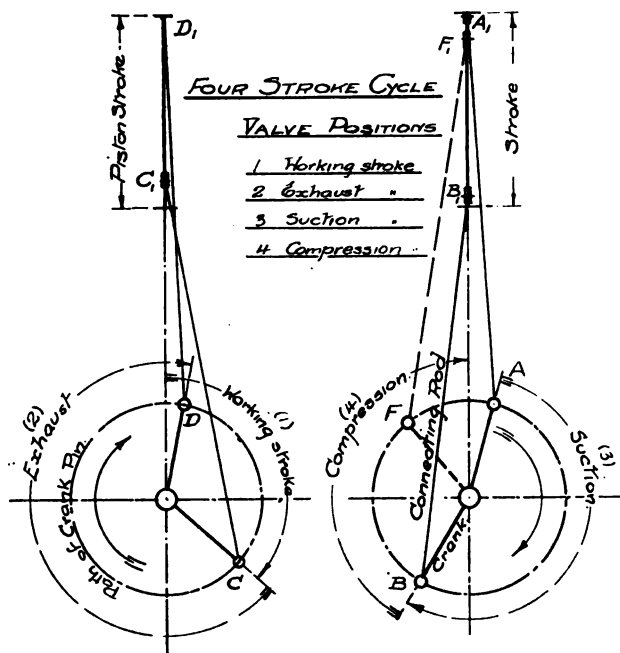


FIG. 13.

twist and turn and force themselves through small holes in the silencer. At the end of the stroke the gases are still at a fairly high pressure—about 40 to 50 pounds on the square inch—and if this pressure was not cleared out of the cylinder before the piston commenced its exhaust stroke a considerable amount of work would be lost, due to the back pressure on the piston because this back pressure on

the piston would be against its direction of motion. The exhaust valve closes a little late in order that every opportunity may be given to get the used-up gas cleared out. If this burnt-out gas was not cleared out as thoroughly as possible it would occupy some of the space which the fresh charge ought to occupy, and thus less mixture would be available for burning during the working stroke. The power of the engine would thus be diminished. C and D (Fig. 13) show approximately the positions of the crank when the exhaust valve opens and closes, C and D being the corresponding positions of the piston.

It should be noted that the time of opening and closing of the valves depends to some extent on the speed of the engine, the general tendency being: the higher the speed, the valves open and close the farther from dead-centre position. For very high speeds and powers the best position for opening and closing of the valves must be found by experiment for each engine. This is called "tuning" the engine.

Grinding in of Valves.—Before leaving the valves it should be mentioned that these require to fit very perfectly on their seats. If they do not fit closely the suction effect during the inlet stroke and the pressure during the compression stroke are to some extent lost, and this reduces the efficiency of the engine. In the course of time, due to wear and to the hammer action of the valve on its seat, very slight holes develop on the working face of the valves and seats. This is called "pitting." The exhaust valve suffers most, as the hot exhaust gases, which when leaving the engine are still at a very high temperature, damage the working surfaces. The remedy for pitting is to grind in the valves periodically with emery flour and oil. The exhaust valve requires grinding in twice or three times as often as the inlet valve. The method of grinding in valves is to rotate the valve by means of a brace with a screw-driver bit, the valve being occasionally lifted in order that the face may not be scored by the constant grinding in one position. Great care should be taken to see that none of the emery is left about the valve, as it would be sucked into the cylinder and cause very rapid wear of the valve guides, piston rings, etc.

Indicated Power.—The work done in the cylinder of an engine is measured by an indicator which automatically draws an indicator card. When dealing with the theoretical performance of an engine, that is, the power an engine ought to develop under ideal conditions, an ideal indicator card is drawn and the actual and ideal cards are compared. In order to show the effect of altering the timing of the spark

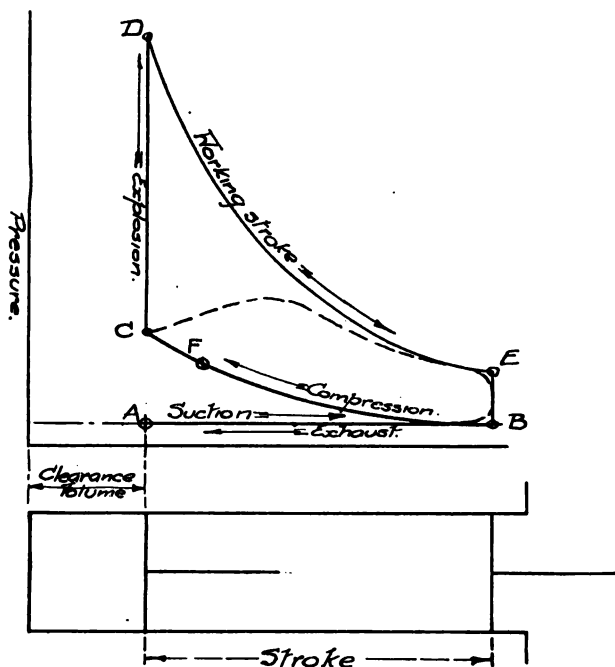


FIG. 14.—Theoretical Work in Cylinder.

it will be necessary to show the differences by means of these cards. ABCDEBA (Fig. 14) represents the four theoretical strokes of the Otto Cycle. AB is the suction stroke, BC the compression stroke, the pressure of 15 lbs. or atmospheric pressure being raised by compression to between 60 and 80 lbs. per square inch. CD shows the great rise in pressure due to the rapid burning of the charge; the spark

taking place at the end of compression C theoretically raises the pressure to D instantaneously. DE shows the decrease in pressure in the working stroke due to the expansion of the gases as the piston moves out. EB and BA shows the exhaust stroke.

Spark Timing.—In practice, if the spark did not take place till the end of the stroke C was reached the card would take the form shown by the dotted line, and as the work done is proportional to the area of the card BCDE a considerable loss of work would ensue. This is due to the fact that the burning of the charge takes an appreciable amount of time, and if the greatest pressure is to be developed right at the commencement of the working stroke the spark must occur at some point such as F some time before the piston reaches dead-centre, thus enabling the stuff to give out most of its heat by the time the end of the stroke is reached.

Spark Advance.—This early sparking is called spark advance. Assuming that the time required for the charge to burn is roughly the same for a given mixture, when the engine is running slowly the spark will not require to occur so early; in fact, if the time of sparking is not made later in slow running the pressure rises too quickly, and tends to stop the engine. The cards shown in Fig. 15 (1), (2), (3), (4), were taken from a motor cycle engine by Professor Callendar, and they show the effect of wrong spark position very clearly. To avoid confusion to the beginner they have been simplified. Referring to Fig. 15, (1) shows an indicator card taken when the engine was running light, that is with the throttle nearly closed. The spark was fully retarded and did not take place till after the dead-centre position. The piston had almost reached the end of its stroke before any considerable pressure was raised behind it, and probably some of the mixture went unburnt to exhaust. The only change made in (2) was to advance the spark to the position shown, the throttle remaining as before. The power developed in the second case, as shown by the area of the card, was twice that developed in the first case for the same amount of petrol used. Card number (3) was taken with the throttle full open and with the spark

very far advanced, the pressure at the end of the stroke being great. Compare this card with number (4), in which the throttle was also full open but the spark had the correct

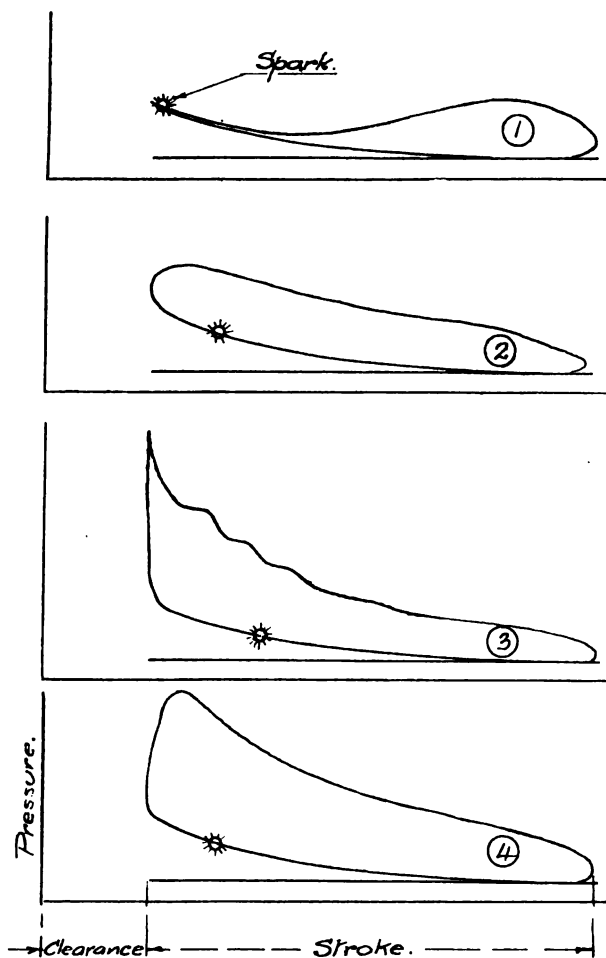


FIG. 15.—Actual Indicator Cards from Petrol Engine.

amount of advance. The power developed in both cases was approximately the same, but in case (3) the greatest pressure was higher and the revolutions were greater than in case (4). The power was therefore developed with less shock and wear on the engine in the latter case. The best position for the spark can only be approximated to by the beginner : only the feel of the engine and the particular note it gives out tell whether the spark is right or wrong. Considerable experience is required to judge this. The retarded ignition, that is, when the ignition takes place about the end of the compression stroke, or a little later, may be used when the engine is labouring, as when the car is climbing a hill, or when for any reason slow running of the engine is desired. In every case when the engine gives out a metallic knock the spark should be retarded, as continued running with the spark too far advanced will damage the bearings at both ends of the connecting rod.

Carbon Deposit.—After an engine has run for some time a deposit of hard fixed carbon takes place on the top of the piston and on the end of the cylinder. This carbon is heated to a white heat during the working stroke, and sometimes it retains sufficient heat to fire the new charge before the proper time. When this occurs the piston heads and the cylinder ends should be cleared of this carbon. This should be done every 3000 or 4000 miles.

Effect of Compression.—In the Otto Cycle the charge is compressed before it is exploded. It can be proved that high compression increases the efficiency of the engine. The amount of compression is proportional to the clearance space (see Fig. 14). By making the clearance space smaller (this may be done by fitting a longer piston) the engine will deliver more power for the same amount of petrol. The table shows this increase in efficiency. The first column gives the ratio of the total volume behind the piston when at the outer end of its stroke to the volume behind the piston when the piston is at the inner end of its stroke ; the second column gives the efficiency if there were no losses of heat anywhere, and the third column gives the efficiency which may be expected under very good working conditions.

Ratio of Compression.	Ideal Efficiency.	Actual Efficiency.
$2\frac{1}{2}$ to 1	·31	·20
3 to 1	·36	·23
$3\frac{1}{2}$ to 1	·39	·25
4 to 1	·43	·28
5 to 1	·48	·30

This means that with a compression ratio of $2\frac{1}{2}$ to 1, only 20/100 or 1-5th of the heat in the petrol used is converted into useful work; whilst if the compression is increased to 5 to 1, 3-10th is converted into work. This shows the value of high compression. There is a limit to the compression that may be used, as high compression pressures entail high explosion pressures and greater wear and vibration in the engine; it makes the engine difficult to start and apt to be noisy. There is also a chance of pre-ignition if the compression is too high, as heat is generated when air is compressed—witness the heat generated at the end of a tyre pump. A good compression pressure is from 70 to 80 lbs. per square inch above the atmospheric pressure when high efficiency is required, such as is necessary for high speed work, but for ordinary touring work a considerably lower figure gives a much more flexible and easy-to-handle engine.

Cooling.—The temperature of the products in a petrol engine cylinder after explosion is very high: it reaches 3000 degrees F., and during the whole of the working stroke it does not fall below 1200 degrees F. This temperature would destroy the metal of the cylinder in a very short time unless precautions were taken to prevent it. A stream of fairly cool water, that is, cool compared with the high temperatures inside the cylinder, is kept circulating round the outside of the cylinder walls and end. This ensures a layer of fairly cool gas next the working surfaces inside the cylinder. This cool gas, being a bad conductor of heat, prevents the great heat in the centre of the cylinder from affecting the oil on the walls of the cylinder and allows the piston to slide freely up and down in its path.

Circulating Water by Pump.—The circulating water abstracts heat from the walls, and it in turn has to be

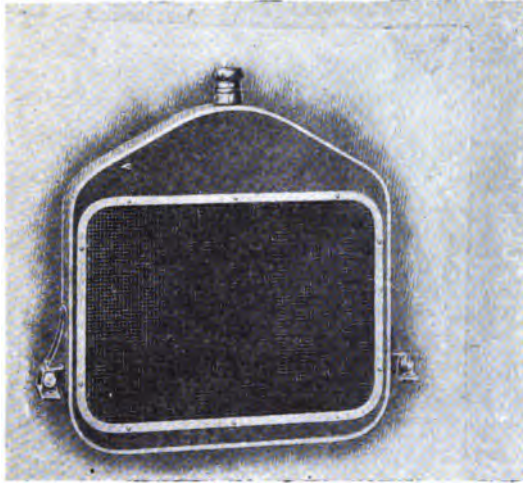


FIG. 16.—Radiator.

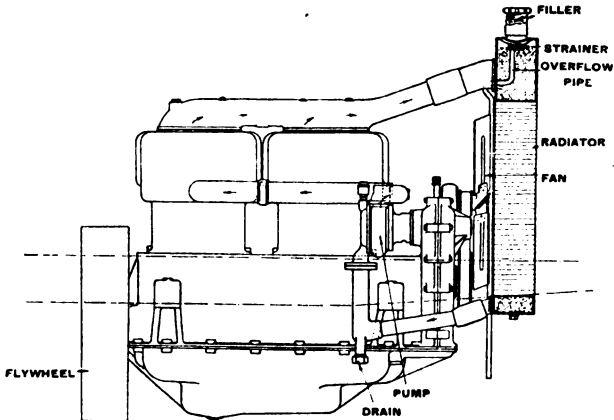


FIG. 17.—Water Circulation. Pump System.

cooled. This is accomplished by sending the water through a radiator (Fig. 16). Fig. 17 shows the arrangement on a Wolseley car, the arrows showing the path taken by the

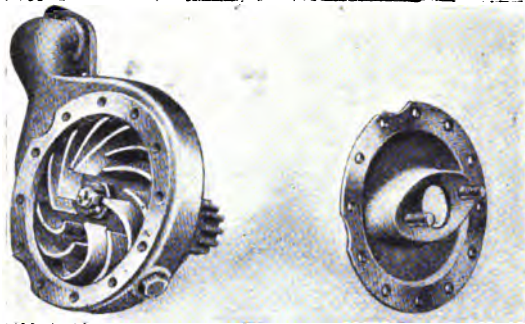


FIG. 18.—Details of Pump.

water. In this case the water is forced round the engine cylinders and so to the top of the radiator by a pump, the internal construction of which is shown in Fig. 18.

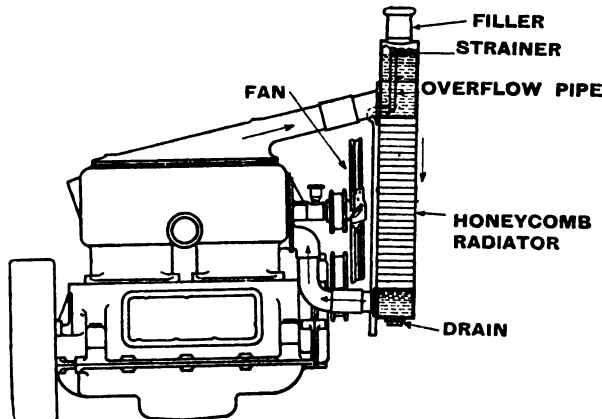


FIG. 19.—Cooling Water Circulation. Thermo-Syphon System.

Thermo-Syphon Circulation.—In engines of a small size the action of the hot water tending to rise to the highest

level in the system is sufficient to cause circulation of the cooling water. This system is shown in Fig. 19. A fan driven at a high speed by the engine is fitted behind the radiator and causes a constant stream of cold air to strike the tubes, and so cools the water as it trickles through. The radiator, Figs. 16 and 17, consists of a large number of flattened tubes through which the water trickles from the top to the bottom. The cooling effect on any hot body is proportional to the surface of the body exposed. For example, in a motor cycle engine ribs are cast on the main cylinder to give a greater cooling surface. A solid block of iron heated in the forge would retain its heat considerably longer than the same amount of heated metal in the form of a thin plate. The form of radiator tube most in use consists of flat thin pipes having a large surface for a small internal area. These are placed close together, with their top and bottom ends entering into chambers or reservoirs of water. The water enters the tube at the top at a fairly high temperature and comes out into the reservoir at the bottom fairly cool and makes its way round the engine again. In the honeycomb radiator the flat tubes are shaped like honeycomb. Another type of radiator tube which is not so often used now is the gilled tube. This has ribs similar to a motor cycle cylinder, the bore of the tubes being much smaller of course.

Lubrication.—All bearing surfaces in a car, as in other machinery, require to be lubricated—crank shaft bearings, big-end bearings, cam shaft, gudgeon pin, the walls of the cylinder, valve stems, etc., all require a certain amount of lubricating oil to make them work freely. There are many methods of lubrication ; usually some form of oil pump takes the oil from the reservoir at the bottom of the crank case and delivers it to the crank shaft bearings and to troughs (Fig. 20) into which a scoop on the big end (Fig. 21) dips and splashes oil all over the inside of the crank case. Oil is also splashed on the walls of the cylinder while the piston is at the top of the stroke. Some of the oil enters a hole in the scoop and so lubricates the big end. The surplus oil runs back into the pump and is used over and over again. Very often some method of indicating whether the oil is circulating is used. Fig. 22 shows the

lubricating arrangement of pump, delivery pipes, oil tank, and indicator, on a six-cylinder Standard car. In a number of cars a visible drip inside a glass tube is arranged so that the driver can see it, and the amount of oil is gauged by

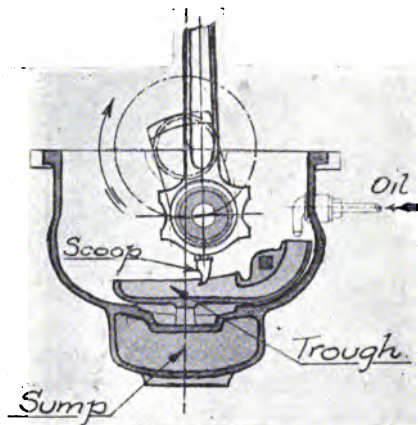


FIG. 20.—Crank Case Section.

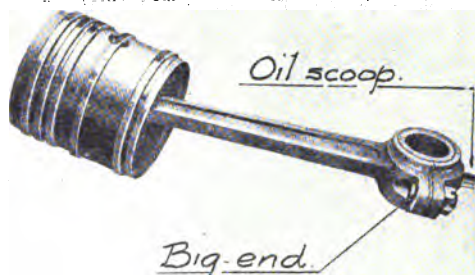


FIG. 21.

the frequency of the drops. In very large and expensive cars the oil is pumped through holes drilled in the crank shaft and webs, pins, etc., to the various bearings.

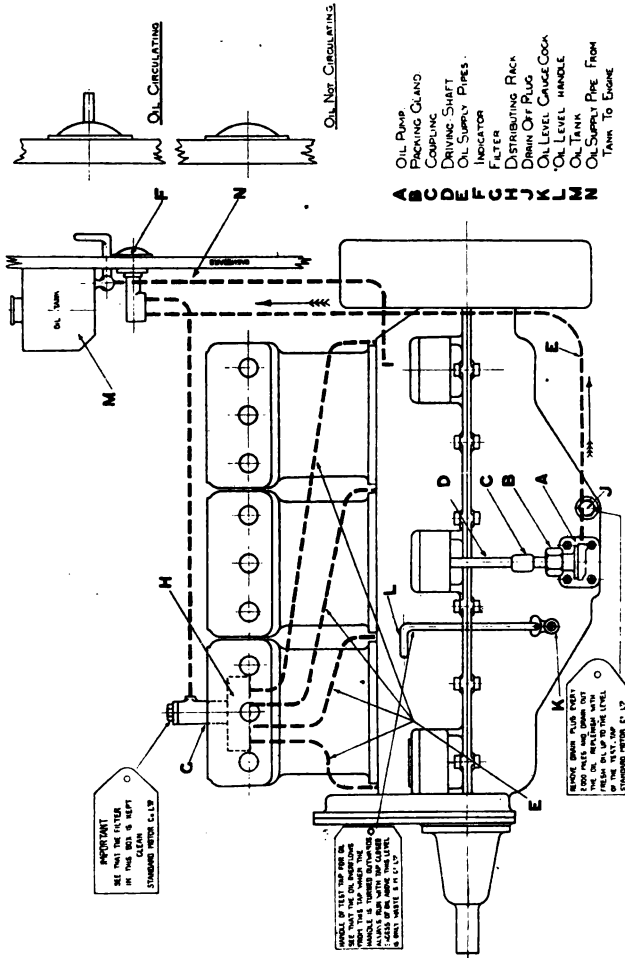


Fig. 22.—Lubrication Diagram for 20 h.p. 6 cyl. Standard Engines.

CHAPTER V

CARBURETTORS

Heat and Work.—In all prime movers the work given out by the engine is obtained by converting heat into work. For example: in the steam engine the heat given out by the coal in burning is transferred in a boiler to the water, which then forms into steam. This steam is supplied to the engine, and the engine converts some of the heat energy stored in the steam into work. This is a wasteful process, as a considerable amount of the heat goes up the chimney unused, and the engine throws away the steam to exhaust with a large amount of heat still in it.

Internal-Combustion Engines.—In internal-combustion engines, the petrol engine amongst them, this loss of heat is partly got rid of by burning the fuel direct in the cylinder of the engine instead of in a separate boiler. When the fuel is to be burnt in the cylinder it requires certain attributes. It must be clean—that is, it must not leave any ash, tar, or other deposit behind in the cylinder. In order that the engine may work well and efficiently the fuel must be prepared for burning by some outside agency before it enters the cylinder.

Petrol.—The fuel mostly used at present in motor car engines is petrol. Petrol is obtained from crude petroleum, which in turn is obtained from springs or wells in the earth or from shale. The crude petroleum is prepared by a process of distillation: that is, by means of the application of heat part of the crude oil is converted into vapour just as water is converted into water vapour or steam when a certain amount of heat is given to it. The unrefined petroleum gives off vapour at varying temperatures. This vapour is led away through a pipe to another vessel and

cooled, the cooling having the effect of condensing the vapour to liquid again. In heating, the temperatures at the commencement of the process are low, and the vapours given off when condensed go to make what we know as the lighter oils—petroleum spirit or “petrol.” When all the vapour is given off at this temperature the heat is increased and another part of the petroleum is vaporised and, as before, condensed, giving what we know as “paraffin.” This process is continued, the temperatures being increased and the resulting oils becoming heavier until there is only a thick tarry material left, known as the residue.

Specific Gravity.—The weight of a given volume of the distilled products increases as the temperature of distillation gets higher ; or, as it is technically called, the specific gravity increases. The lighter oils which form petrol have a specific gravity of 0·66 to 0·75, water being equal to 1. The paraffin oils have a specific gravity of about 0·75 to 0·82, and so on. As there is only from 4 to 15 per cent. of the petroleum light enough to come over as petrol, and as the demand for a suitable motor spirit is increasing very rapidly, strenuous efforts are being made to utilise the heavier or paraffin oils. When this succeeds a much larger supply of suitable fuel will be available, as crude petroleum contains from 20 to 50 per cent. paraffin.

Other Fuels.—The constantly increasing cost of petrol has caused consumers to turn their attention to other suitable fuels, the best known of which are alcohol and benzol. These latter are quite suitable for use in engines even as designed at present if slight modifications are made, and if the high duty and other Government restrictions on alcohol are removed it will soon form quite a considerable addition to the fuels available for motor car engines.

Carburation.—All the above fuels or oils consist chiefly of a combination of the elements carbon and hydrogen, and are called hydrocarbons. If the respective weights of these elements in the oil are taken, carbon predominates greatly : therefore, when the air supplied to the engine to burn the fuel is impregnated with finely-divided particles of the oil it is said to be carburetted, and the apparatus which performs this operation is called a carburettor. The proportions of

air and hydrocarbons which go to make up a mixture which will burn rapidly when ignited are quite definite, and if there is either too much air or too much petrol in the mixture it will burn too slowly or not at all.

A Simple Experiment.—This can be proved by an interesting little experiment. Take a small tin having a fairly tight lid, and punch a quarter-inch hole in either end. Fill the tin with coal gas by taking off the lid and holding it upside down over a gas jet, allowing the gas to blow through the top hole for some time in order to expel the air in the tin. Put the lid on, turn the tin with the lid upwards, and apply a light to the hole in the lid: the issuing gas will burn with a flame like a small gas jet; but, strange to say, the flame, although in direct connection, does not explode the gas in the tin. As the gas burns at the top the amount burnt is replaced by air, which enters through the hole in the bottom, and the tin now contains a mixture of gas and air. When the proportions of gas and air left in the tin are such that rapid burning can take place the flame travels inwards, igniting the whole of the remaining mixture, and the lid of the tin is blown off with a considerable explosion, showing that when the proportions of coal gas (which also consists of hydrocarbons) and air are correct we get rapid or explosive burning. There are many forms of carburettors in use, and new designs are coming forward every day. Some of these claim to be particularly efficient under certain conditions of working; some are designed to give power without paying much attention to economy; others give silent running or economy, and so on. Only the main principles governing the working of a carburettor will be gone into, and the remarks will be confined to the spray-jet type with float feed.

What is required.—It will be necessary to get some idea of the work a carburettor has to do. The stuff supplied to the engine on the suction stroke consists of a large quantity of air, carrying in suspension finely-divided particles of petrol, or, as it is called, atomised petrol. During the suction and compression strokes this atomised petrol is converted by the heat of the engine into petrol gas, which is then ignited and burned; the heat generated thereby increasing the pressure in the cylinder and driving

the piston out, gives the working stroke. The carburettor has to measure out the proper quantity of petrol for the power required, break it up into finely-divided particles or vapour, and distribute these particles uniformly over the correct volume of air which must be supplied. Under most conditions of running there is a certain mixture, consisting of a definite quantity of petrol to a definite amount of air, giving the best results, and the carburettor has to give this mixture as nearly as possible.

Simple Types.—Considering the simplest type (shown diagrammatically in Fig. 23) : a plain pipe has a jet from which petrol is issuing in the form of spray, and the air which is being sucked through the pipe by the suction of

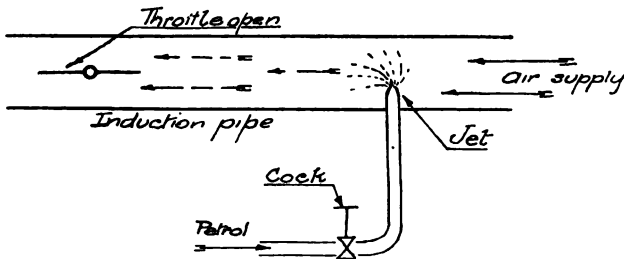


FIG. 23.

the engine picks up the petrol as it passes over the jet and so becomes impregnated with petrol vapour. The amount of air required is controlled by opening and closing the throttle (shown full open in the figure), and the amount of petrol by the opening and closing of the cock. This method is too crude, and great skill on the part of the driver is required to get anything like the correct proportions. In some of the early aeroplane engines a carburettor of this type was used.

Float Feed.—Fig. 24 shows an advance in design, the petrol cock being done away with and the amount of petrol automatically measured off by a valve which is operated by means of a float. Petrol flows from a tank through a pipe to the bottom of the float chamber, the tank being

either higher than the carburettor or having pressure acting on the surface of the liquid, causing it to flow into the float chamber until the valve closes. As the depth of the liquid in the chamber increases the float rises and lifts the two small weights, which in turn act through levers on collars at the top of the needle valve, pushing it down and closing the orifice at the bottom. The size of the float and the weights are adjusted so that when the petrol reaches a level just below the top of the jet the needle valve closes and the flow into the chamber is stopped. This float-chamber method of measuring out the petrol is almost universal,

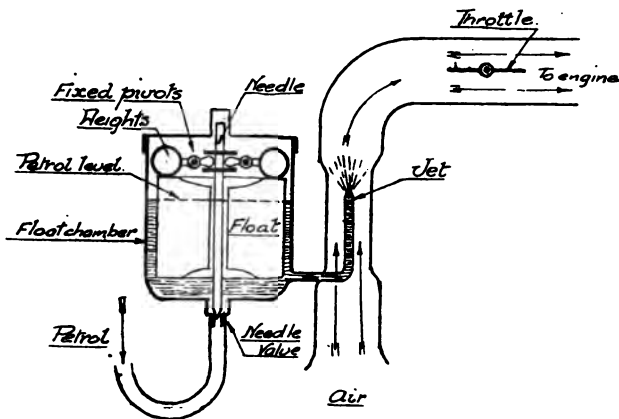


FIG. 24.

though the details of design vary to some extent. The suction stroke of the engine sucks the petrol out of the jet and at the same time draws air through the jet chamber, which is made narrower at the jet in order that the mixing effect between the air and the petrol spray may be more marked. This narrower part is sometimes called a choke tube. This form of carburettor will give the correct mixture—that is, the correct proportion of petrol vapour and air—at one particular speed of the engine; at lower speeds the mixture has too little petrol in it, and at higher speeds too much. This is due to the fact that if the flow of air is increased the flow of petrol is increased in a greater

ratio ; thus if the original mixture is correct in proportions the new mixture will be too rich. This set of conditions would happen when the speed of the engine is increased. Another disadvantage is the erratic behaviour of the flow from the jet when the speed of the air passing over it is too slow.

Extra Air.—Fig. 25 shows a modification in which the design is altered so that the correct mixture is given at very slow or starting speeds ; and as at all higher speeds the mixture is too rich an extra air-inlet is opened, thus diluting

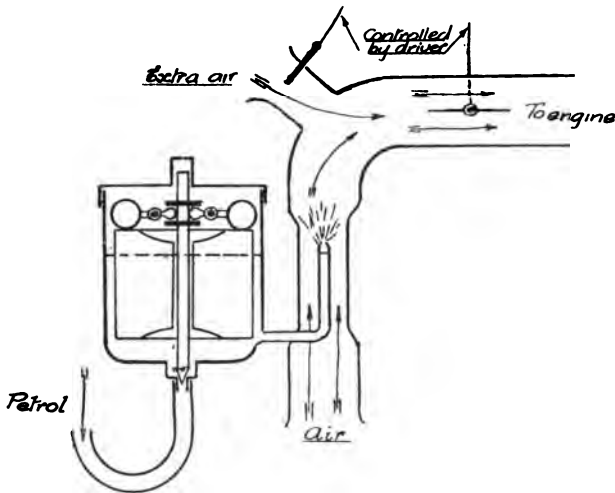


FIG. 25.

the mixture. The amount of extra air is controlled by the driver, thus giving him two levers to work—the throttle and the extra air—in order to get the best mixture. A certain amount of skill is required to judge the correct amount of extra air.

Automatic Air.—The next development was to arrange that the varying suction of the engine due to extra speed should automatically operate the extra air-opening, thus giving the driver only one lever to control, namely the

throttle. One of the first successful automatic carburettors of this type was the Krebs Panhard, shown in Fig. 26. The float chamber is not shown. At low speeds all the air is taken in across the jet, and, mixing with the petrol vapour, goes straight past the piston type of throttle shown

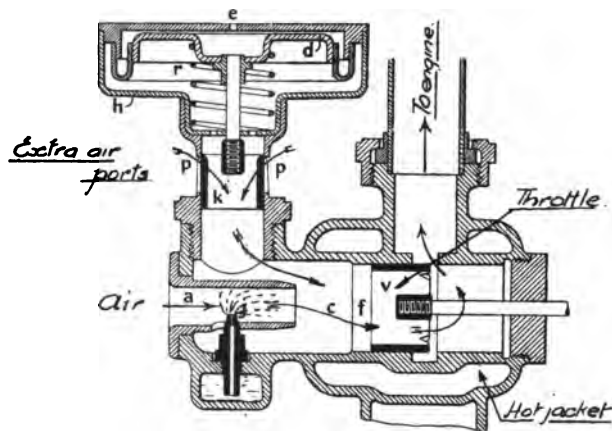


FIG. 26.—Krebs Carburettor.

to the engine. At higher speeds the suction is sufficient to draw down the large-area flexible diaphragm *d*, to which is attached a hollow piston *p*, against the light spring *r*, and so to open extra air-ports at *pp*, giving more air for the dilution of the too-rich mixture coming through the choke tube *a*.

Strength of Mixture.—A point which should be noted is that while theoretically the strength of the mixture should always be the same, in practice, due to various causes, in order to get sufficient power at low speeds, economy of running has to be sacrificed to some extent, and a mixture which is somewhat richer than the theoretically correct mixture has to be used. The method of supplying the extra air shown in Fig. 25 has now been discarded, and other methods adopted. A common method is to vary the supply of petrol by varying the size of the opening or orifice in the jet, the White & Poppe carburettor being an example of this

type. The moving of the throttle, which is of the barrel or cylindrical type, also moves a cap over the jet. The holes

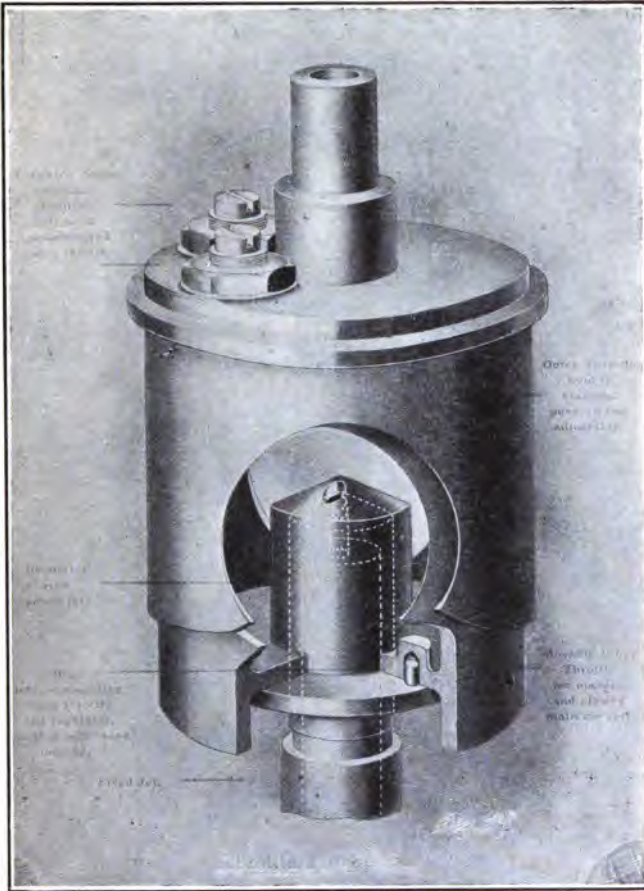


FIG. 27.—Throttle and Spray.

in the jet itself and in its cap are eccentric, so that the area of the jet varies with the opening of the throttle—that is, it varies with the supply of air. These variations are

adjusted by the makers to give a correct mixture at all speeds. The driver has only one lever to control in ordinary running. Fig. 27 shows the arrangement of the throttle and the variable jet, the air going straight through over the jet.

Two-Jet Carburettors.—Another method of getting a sufficient supply of petrol in the mixture at low speeds is to

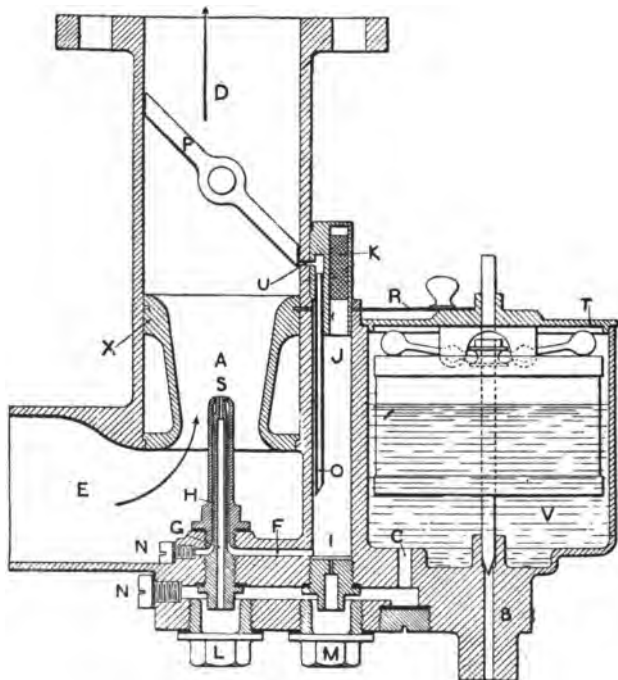


FIG. 28.—Zenith Carburettor.

have a special jet for working under these conditions. The Zenith carburettor shown in Fig. 28 is an example of this type, the secondary jet I filling the small chamber J ; and although the suction due to slow running may not be enough to cause petrol to flow through the main jet, it will suffice for drawing enough liquid up the small tube O,

through the opening U, when the throttle is slightly opened, thus giving a small quantity of fairly rich mixture, which keeps the engine just turning over. When the throttle is opened farther the concentration of suction is removed from the opening U and the auxiliary jet I goes partly out of action. This carburettor shows a choke tube (A) in the vicinity of

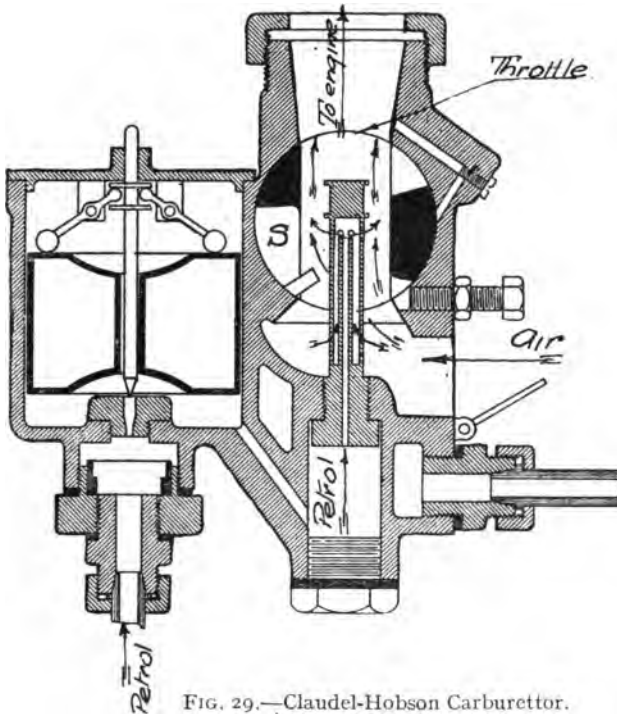


FIG. 29.—Claudel-Hobson Carburettor.

the jet, which greatly assists in the thorough mixing of the petrol vapour and the air.

Restricted Air Types.—In several of the latest types of carburettors a fairly rich mixture is assured at low speeds by concentrating the air supply immediately round the jet. This is equivalent to making the choke tube very small.

The Claudel-Hobson carburettor embodies this method. Fig. 29 shows this type. The jet has an annular chamber round it; air flows through this space, and, meeting the petrol as it is sprayed out horizontally at the top of the jet, it is thoroughly saturated with petrol vapour. The throttle is in the form of a horizontal barrel or cylinder, the top half of which acts as the throttle, opening up or cutting off the area of the pipe to the engine. The lower half has a kind of large slot in it at S, which forms the variable choke tube. The fact that some air is drawn through the annular chamber round the jet assures the efficient mixing of this air with the petrol.

Another Type of constant suction due to the concentration of the air stream is the S.U. carburettor (Figs. 30

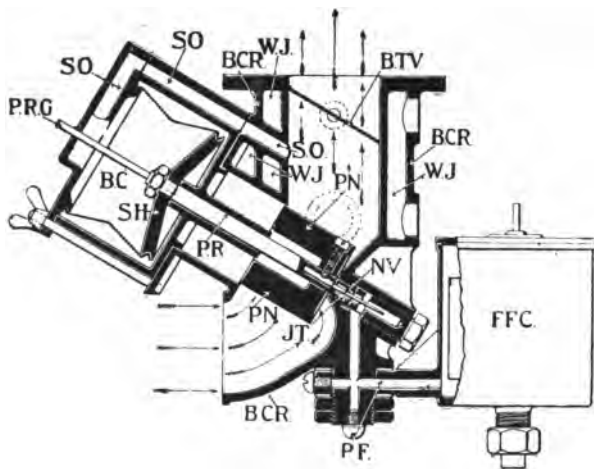


FIG. 30.—S.U. Carburettor.

and 31). The air enters at the bottom, and at slow speeds it is concentrated and passes through a small space over the needle valve or jet NV and so to the engine. As the speed of the engine increases the greater suction acts through the pipe SO on the back of the suction head (SH) and so draws up the piston (PN). At the same time the upward movement of the piston in the direction of PR opens up the jet

by withdrawing a needle. The size of the opening in the jet and past the piston for the air at any speed is such that a correct mixture is given.

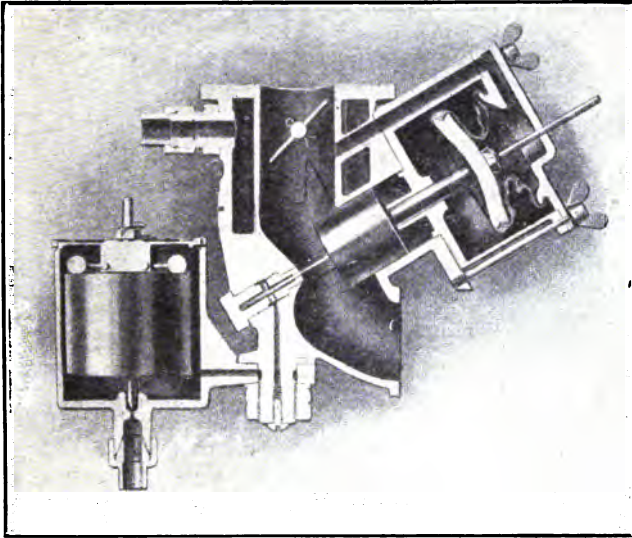


FIG. 31.

Hot Jackets.—In a great many carburettors provision is made for heating them by means of a concentric chamber or jacket through which hot water from the cooling system, or exhaust gases, circulate. This is to supply part of the latent heat of vaporization and keep the carburettor from freezing up, and also to reduce the viscosity of the petrol and to make it flow more rapidly. Another method of supplying heat to the carburettor is to draw the air supply from the neighbourhood of the exhaust pipe. In hot countries and in summer weather in temperate countries the heat in the air is sufficient to supply the necessary heat to the carburettor.

CHAPTER VI

IGNITION (ACCUMULATOR AND COIL)

Ignition.—In an internal-combustion engine, when the gas and air have been compressed in the cylinder, some method of igniting the charge is required. In the early days of motor car engines this was accomplished by keeping a tube of suitable material at a red heat by means of a Bunsen flame playing on it. This was found to be inefficient, as the flame was liable to be extinguished and there was no simple method of varying the timing of the ignition. The hot tube was therefore soon displaced by electric ignition—that is, an electric spark was made to occur inside the cylinder of the engine at the proper time and so fire the charge. The complete theory underlying the production of electric sparks is of an involved nature, and to the non-technical man seems very intricate indeed, but it is hoped that by giving only the necessary facts in a simple manner a working knowledge of ignition as applied to the motor car engine may be imparted. It will probably be necessary for those studying the matter for the first time to read slowly and carefully, and to go back over the facts several times until these are impressed on the mind.

The Current.—The study of electricity cannot be commenced by stating what it is: all that can be done is to state what it can do under given conditions. The flow of electricity, called the current, can be obtained in two ways: it may be obtained from a store carried on the car, this store being sufficient for four to eight weeks' running; or it may be produced as required by means of an electromagnetic machine driven from the engine. In the first method the electrical energy is stored in an accumulator, which requires to be charged periodically as this energy is

used up ; in the second method the current is obtained from a small dynamo or magneto, which does not require any attention, except oiling, for perhaps four or five years.

Accumulator and Coil.—Although most cars obtain the current required for the spark by the second (or magneto) method, and in a large number of cases accumulators are not carried, it will be convenient to consider the accumulator and coil method of supply first, because in all other methods a coil is incorporated in the system. The current supplied by either the accumulator or the magneto is a low-pressure

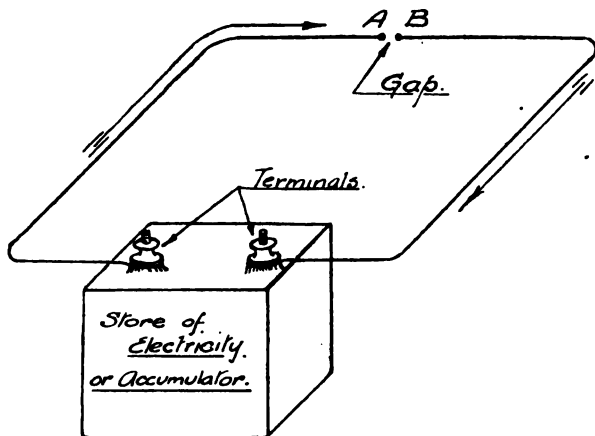


FIG. 32.

current—or, as it is technically called, a low-voltage current. In order to obtain a spark a high-pressure or high-voltage current is required. The function of the coil (so called because the wires carrying the current are coiled round the central core) is to convert the low-voltage current given by the accumulator, the dynamo, or the magneto, into a high-voltage current. Before going farther, however, it will be necessary to consider some facts with regard to electricity, and some of the commoner terms used must be explained.

Electrical Definitions.—Voltage is that attribute of electricity which corresponds to pressure in steam or in water. When the voltage is very high—in the region of

10,000 volts, say—the current is called a high-tension current, and when the voltage is low the current is called low tension. Amperage in electric work corresponds to quantity in water or in steam. A certain current of electricity may have a large amperage and a low pressure or voltage, or exactly the same amount of electrical energy may flow in the form of a current of small amperage and high voltage.

Insulator.—Like steam under a low pressure, electricity with a low voltage can easily be confined to its pipe or path, but when the voltage is very high it is a very difficult matter to confine it. Instead of a pipe of metal, as in the case of steam, electricity must flow through a pipe of insulating material with a conducting material inside. There are many kinds of insulating materials, but those oftenest used are made chiefly of rubber compounds. Other insulating materials are porcelain, mica, fibre, glass, celluloid, paraffin wax, etc. These materials, which confine the electric current to its proper path, are called insulators.

Conductors.—The materials—usually in the form of wires—through which the current will flow freely are called conductors. Most metals are conductors, but some are more effective in this respect than others. The best conducting metal is silver ; but copper is nearly as good, and is less costly. Carbon is also a conductor of electricity, and is used considerably in motor work, especially in cases where current has to be picked up from a moving part and transferred to a fixed part.

Terminals.—On an electrical machine, on a dynamo, or on an accumulator, the connections to which the cables carrying the current are fixed are called terminals. Terminals must always be kept scrupulously clean, or the flow of electricity may be interrupted.

Earth or Return.—Before an electric current can be induced to travel through a conductor there must be a complete circuit of connections from the supply through the conductor to the point at which the current is going to work and back again from that point to the supply. From the source of supply to the point of application there must be a direct path through a conducting wire ; but from

there the current may be allowed to travel as it pleases through the iron framework of the motor to the source, thus saving the provision of a special wire. This is called earthing the return, or return through the frame.

Sparking.—The method of obtaining a spark from an electric current is to lead it through a conducting wire to a point where the continuity of the wire is broken by a small space, and to make the current jump this space before it can return to the source. This arrangement is shown in Fig. 32; but here, though there is an ample quantity

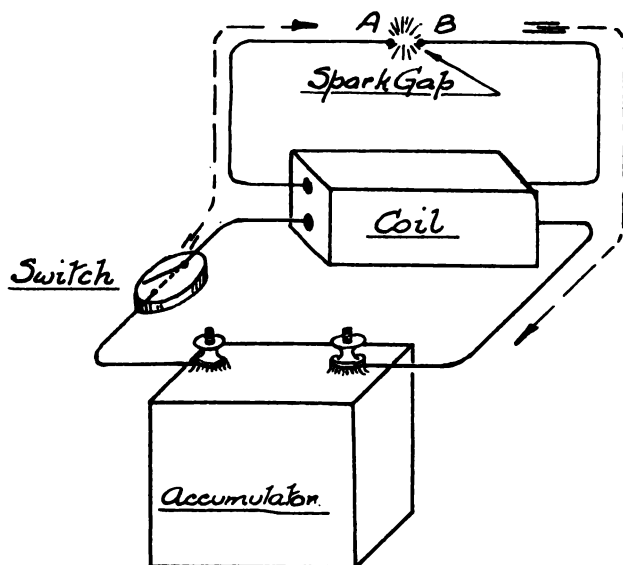


FIG. 33.

available, the source is a low-tension one—that is, the voltage would not be sufficient to make it jump from A to B, and so cause a spark. A spark could be obtained if B was made to touch A and was then rapidly pulled away again, but it has been found inconvenient to do this inside the cylinder of an engine. To cause the current to jump the gap it is necessary to convert the low-tension current

coming from the source into a high-tension current. This is done by means of a coil (shown in Fig. 33) which converts a voltage of about four to one nearly three thousand times as great—sufficient to rupture the insulating properties of the air and burst through from A to B, and so return to the source. It is difficult to find an analogy for this in everyday life, but one which is approximately the same may be shown with water pipes. Assume that the water pipe A

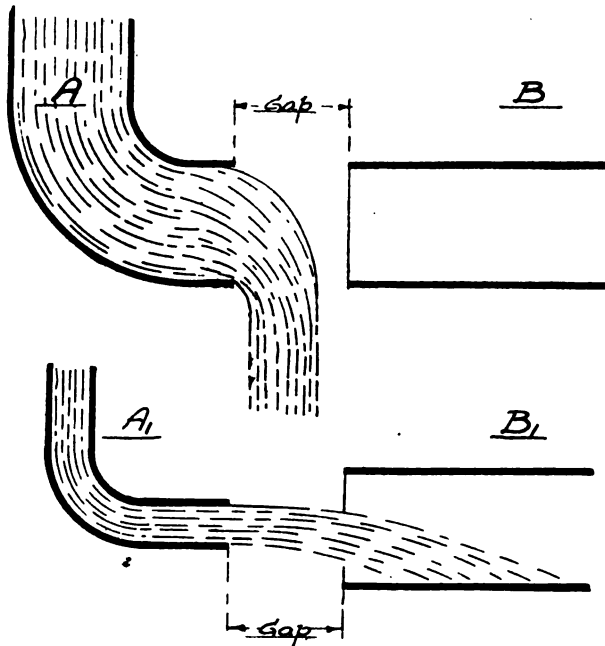


FIG. 34.

of the upper two in Fig. 34 is flowing nearly full but with very small velocity—that is, the pressure behind the water forcing it through the pipe is small. The water simply drops over the edge of the pipe, and none of it reaches pipe B. It cannot jump the gap. Assume now that the same quantity of water has to be passed through the small pipe A1 in the lower two pipes in the figure. It is evident

that the velocity of the water must be very much greater—that is, the pressure behind it must be more. The water leaving A1 will stream out as shown and enter the pipe B1. So in the case of the electrical current: there is a large amperage or quantity passing with a low pressure or voltage, and this is converted by the coil into a small amperage or quantity passing with a very great voltage or pressure. This great pressure enables the current to jump the gap and so give a spark.

Switch.—In Fig. 33, unless some of the wires were disconnected from the terminals the current would continue to flow and give a continuous succession of sparks at the gap. This would soon use up all the current stored in the accumulator. It is not convenient to disconnect whenever sparks are not required, so the wire is cut and one end made movable. When the current is not required the movable part of the wire is moved out of contact, as shown by the full-line position; when the current is required the movable part of the wire is swung round to the dotted position shown. This arrangement is called a switch.

The Induction Coil.—While the amateur motorist is not concerned with the electrical and magnetic principles, or the reasons underlying the action of an induction coil, a simple statement of what happens should be easily understood; and as in the magneto ignition, as well as in dynamo ignition incorporated in some cars which have electrical starters, a coil is necessary, the time spent in mastering this will be well spent. Fig. 35 shows the simple accumulator and coil. The coil consists of the low-tension wire—or primary, as it is called—wrapped round an iron core. On the same core, outside the primary wire, is wrapped another wire very much thinner and having a great many more turns. This outside wire is called the secondary, and is arranged so that a gap is left between its ends. An interruption or break in the primary is shown at B. Assume that the primary is closed, then the current flowing through it will cause the central core to become magnetised. Break the current, or cut it off at B, and immediately the core ceases to be a magnet and the breaking or stopping of the flow of the current in the primary wire will cause or induce

a current in the secondary wire with a high enough voltage to make it jump the gap at A and so cause a spark there. In place of breaking the primary at B by hand a rotating

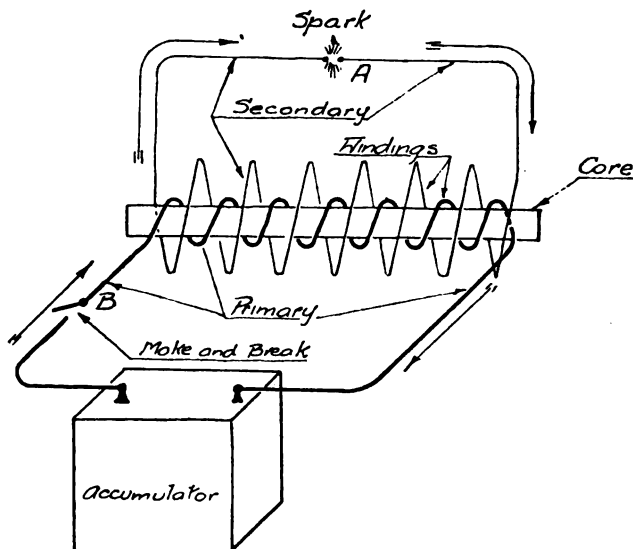


FIG. 35.

piece (or cam) driven by the engine can be arranged to do this, and give a spark as often as wanted.

Trembler Coil.—In the system just described only one spark is given, but it has been found that better results can be obtained if a number of sparks are given off in rapid succession; and as the method explained for breaking the primary is too slow, some other method is required. The method used is that incorporated in the trembler coil shown in Fig. 36. The fact that the central coil is a magnet as long as the primary current flows is made use of to attract a block of metal (B) mounted on the end of a fairly rigid spring (S) which keeps it normally in contact with the screw P. The primary current flows from the accumulator in the direction of the arrow through the screw P to the block B, down through the spring S and up through the coil of wire wound round the core, and so back to the

accumulator. This flow of electricity causes the core C to become a magnet and to attract the block B away from the screw P against the springing action of S, which tends to resist this movement, thus breaking the primary and causing a spark at A, as explained before, in the secondary. But the flow of current in the primary being cut off by this action, due to B leaving P, the core ceases to be a magnet and the spring S forces the block B back against the screw P

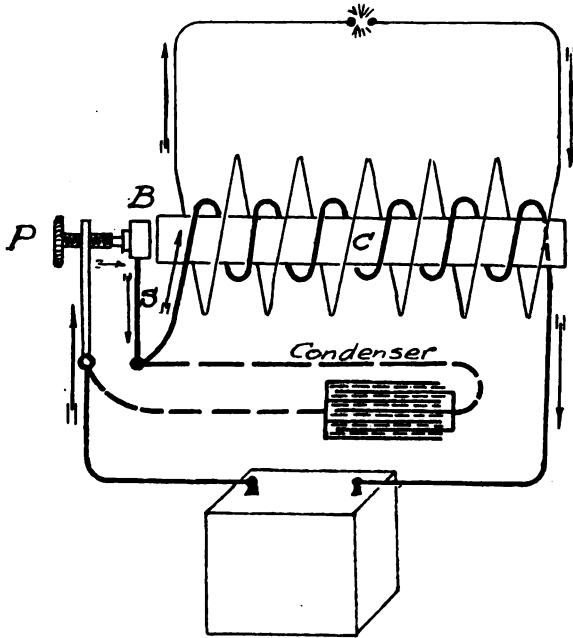


FIG. 36.

again, and so the whole action occurs over again. In some coils this cycle of operations takes place as many as 5000 times per minute. In order to get the best effect by trial and to allow for the wear of the points of contact between the screw P and the block B, the screw is made adjustable. To increase the magnetic effect the central core is made up of a large number of soft iron wires bound together in place of a single bar.

Condenser.—When a body is travelling at a high speed it is extremely difficult to stop it suddenly. Similarly when a circuit through which current is flowing is broken suddenly, there exists the same difficulty in stopping the surge of the current when the break takes place at the trembler points and in preventing it jumping across and causing a spark. This surge of current and resultant spark is bad, for two reasons: it is bad because a certain amount of current is wasted, and it also retards the demagnetisation of the central core, thus causing the current which is induced in the secondary to be of less pressure. It would also prevent the rapid action of the trembler and render it ineffective. To get over these difficulties a condenser is incorporated. This consists of two complete sets of tinfoil plates insulated from each other; and in place of the current passing across the point of contact of P and B, when these are separated it passes into the condenser, which stores it. The advantages gained from a condenser may be stated as follows: economy of current; rapid interruption of the flow of current in the primary, thereby giving a hotter spark at the break in the secondary; it accelerates the motion of the trembler; it acts as a cushion to the surge of the current through the primary and gives back the work stored by this cushion in much the same way as the cushion on a billiard table stops the ball and returns it with an almost equal force without putting any great strain on the ball or on the table.

Summary.—Taking these actions in rotation: (1) The switch is turned on, and the flow of current round the primary causes the core to become a magnet; (2) this magnet attracts the metal block B, drawing it out of contact with the point of the screw P, thus breaking the primary circuit; (3) the break in the primary causes the core to become demagnetised, this inducing a high-tension current in the secondary; (4) the spring S pulls the block B back into contact with P, so completing the primary circuit again; (5) this cycle of actions occurs very rapidly indeed, causing a succession of sparks at the gap in the secondary.

Application to an Engine.—As long as the switch is in, the sparks given at the gap in the secondary will be continuous; but the sparks must only occur at the proper

time in the cylinder, and arrangement must be made to obtain this. Fig. 37 shows diagrammatically the arrangement for a single-cylinder engine. The coil in Fig. 36 is represented by the box in Fig. 37, there being four wires—two for the primary current and two for the secondary. The primary wire coming from the right-hand terminal of the accumulator passes first through the permanent switch at S and so to a piece called the wipe, which is supported by the flat circular plate P but is insulated from it. That

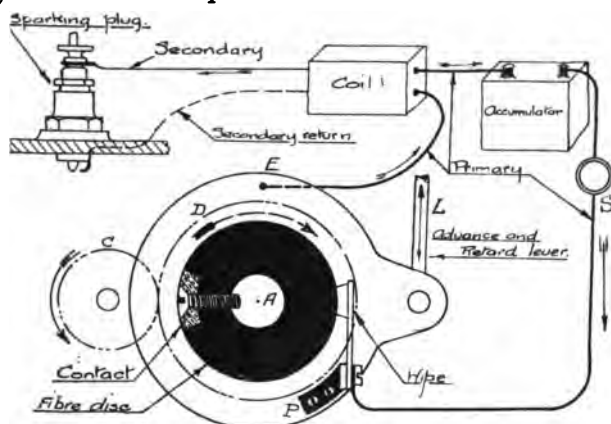


FIG. 37.—Application of Accumulator and Coil to an Engine, showing Variable Timing.

is, the current cannot get farther than the top of this wipe, which rubs on the insulating material of which the inner or fibre disc is made. This fibre disc has a brass piece or contact let in to its surface which has a screw going through the disc to the central shaft A, which is part of and projects from the flat plate P. The fibre disc is made to rotate at half the engine speed by means of the gear wheels CD shown by dotted lines, and when the contact comes opposite the wipe the primary current can flow through from the wipe to the contact piece down the screw to the shaft A and so up the flat plate to where the continuation of the primary is led away at E to the coil. The whole arrangement is simply a rotating switch in the primary timed so that when the contact is passing the wipe, thus completing the primary,

a succession of sparks is given in the cylinder. The two-to-one reduction of speed is due to the Otto Cycle having only one firing stroke every two revolutions.

Advance and Retard.—It was seen earlier that, due to different conditions of running, it was desirable that the time of sparking in the cylinder should vary. This can be done by moving the lever L up and down, causing the plate P to move with it and thus altering the position of the wipe. If the rod is pulled up, it is evident that the wipe will meet the contact earlier—that is, the spark will be advanced; and if pushed down, the time of sparking will be retarded.

Sparking Plug.—The secondary is led from the coil to a sparking plug and connected to this outside the cylinder.

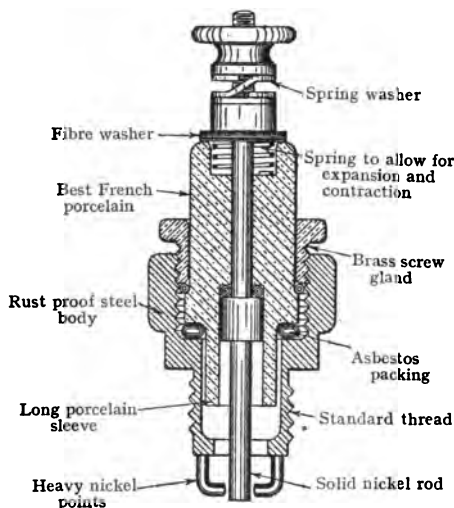


FIG. 38.

The current flows down the central rod of the plug (Fig. 38), which is insulated by the porcelain from the external casing; jumps across the gap at the bottom, causing a spark inside the cylinder; and so through the outer casing of the plug to the metal of the engine cylinder, this being the earth or return. By a slight rearrangement of the wiring and by having four connections a four-cylinder engine can be fired.

CHAPTER VII

IGNITION (THE MAGNETO)

The Magneto.—As was stated earlier, in magneto ignition the electric current in the primary is generated by means of a magneto-electric machine. When a wire is passed through between the ends of a magnet it cuts across a number of lines of magnetic force which always exist between the ends or poles of the magnet. This cutting the lines of magnetic force causes a current to flow in the wire, as can be shown experimentally if the ends of the wire are connected up by means of conducting cables to an instrument for indicating the flow of electricity (see Fig. 39). This fact is made use of in a magneto. A coil of wire is made to rotate between the arms of a magnet and cut the lines of force, thus generating a current of electricity in the coil. The current generated is a low-tension one and requires to be converted into a high-tension current before it can cause a spark in the engine cylinders.

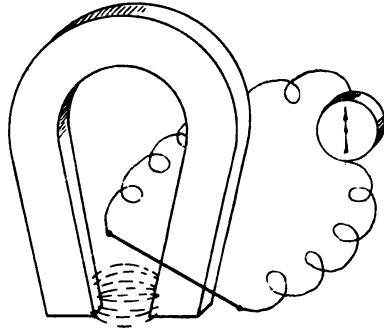


FIG. 39.

The Magnets.—Fig. 40 shows the magnet, which consists of six pieces of hardened steel, together with two pole-pieces which are made circular internally in order that there may be as little air gap as possible and in order

that the lines of force may alter in a certain way as the central H-piece or armature goes round.

Fig. 41 shows the armature before and after winding, and it should be noted that the windings lie parallel to the armature shaft. The primary wire in which the low-tension current is generated lies next the connecting piece for the two curved ends. The secondary wiring—which

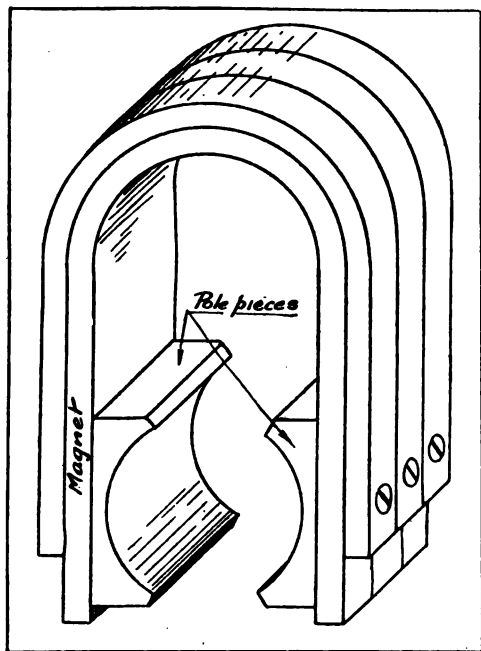


FIG. 40.

is very much finer, and of which there are many more turns—is wound outside the primary in very much the same way as in the coil. (See last chapter.)

Fig. 42 shows the armature without its wiring in place between the poles of the magnet. Fig. 43 represents diagrammatically the armature with the primary wound round it, and it is so represented as turning in a right-hand direction. In this figure the fainter dotted lines show the

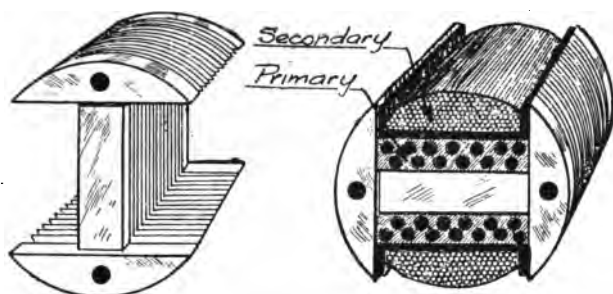


FIG. 41.—Armature before and after winding.

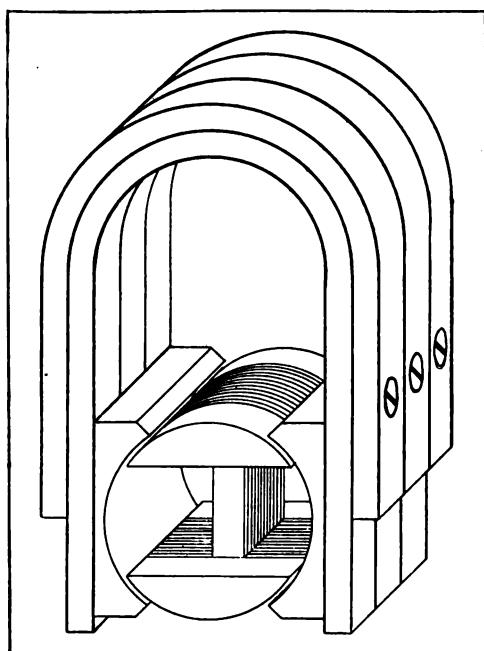


FIG. 42.

path of the lines of magnetic force, these preferring the easier path through the conducting metal of the armature to the jump across the air gap. The fact to note in this figure is that these lines of force pass down through the coil from the top in the position shown, and a very short time later, when the armature has turned as far to the right as it is now to the left, the path of the lines of force will have altered to that shown for the dotted position of the armature because this is now the easiest path (see Fig. 43).

In order to accomplish this the portion of the lines of magnetic force at A must have jumped to A_1 , and the

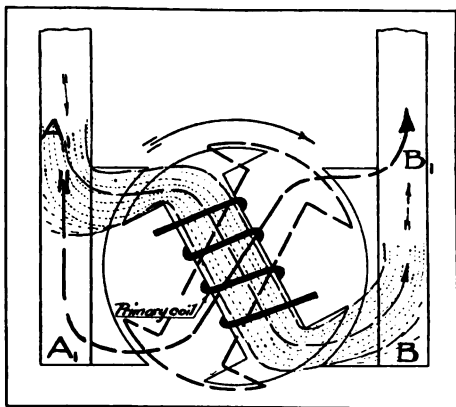


FIG. 43.

portion at B to B_1 . In doing this these lines of force must have cut across the primary wire in the opposite direction to which that wire is travelling. Due to this, as explained before, a low-tension current is generated in the primary wire. As in the case of the coil, this primary current is of too low a voltage to jump across a gap in the circuit, and it has to be converted into a high-tension or high-voltage current. This is done in a manner similar to that explained in the last chapter, but instead of breaking the primary circuit by means of a trembler coil it is broken mechanically by means of a pair of opening points situated at one end of the magneto, to which the current is led.

Fig. 44 shows this arrangement, the right-hand end of the magneto being shown separate from the armature for clearness. The heavy lines show the path of the primary current, and the light lines the path of the secondary. The primary goes through the centre of the right-hand end, through the contact breaker, and returns through the frame of the magneto just below the condenser, thus completing the circuit. At the contact breaker the current is broken by the movement of the little right-angled crank pivoted at its corner. Fig. 46 shows this bell crank, as it is called, with the platinum points just open at K. One end of the

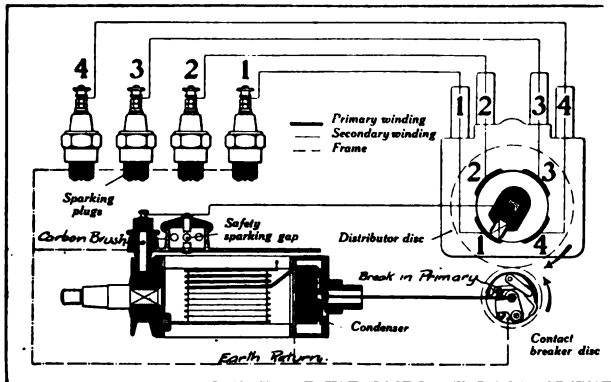


FIG. 44.—Wiring and Path of the Primary and Secondary Circuits in a Magneto.

crank when rotating strikes against a raised piece in the cover, thus opening the points against the spring which keeps them closed. The secondary or high-tension current is led through at the left-hand end to an insulated collector wheel going round with the armature, from which it is collected by means of a carbon brush and taken along to a rotating distributor placed just above the contact breaker. Here it is distributed through four brass wipes set in an internal cylinder made of insulating material to the respective sparking plugs. This distributor is driven by means of the 2 to 1 spur wheels represented by dotted lines. The return of the secondary is through the frame

of the engine to the frame of the magneto, and so back to the coil.



FIG. 45.

- F. Condenser.
- G. Drive to distributor.
- H. End of magneto carrying mechanism for break in primary. (See Fig. 46.)
- A. Spindle to which driving wheel is keyed.
- B. Ball bearings on which armature runs.
- C. Collector ring for high-tension current.
- D. H piece of armature.
- E. Armature windings.

Figures 45 and 46 show photographs of the armature and of the contact breaker.

Safety Spark-gap.—Should anything happen to the plugs so that the electricity generated in the magneto is not used up, say due to a sooted plug—that is, a plug in which a little piece of carbon or some oil has completed the circuit and closed up the gap at which the spark should take place—this electricity would go to heat the armature windings and might seriously damage the machine. In order to avoid this, a kind of sparking-gap is arranged in the high-tension circuit just beyond the collector (see Fig. 48, No. 4). The gap between the points



FIG. 46.

L. End of bell crank lever pivoted at P. A raised cam strikes L and opens the gap as at K, thus breaking the primary.
M. Flat spring keeping gap closed.

is made very much greater here than in the sparking-

plug proper, in order that there may not be any danger of the spark occurring at the safety-gap under normal conditions. In the single-cylinder magneto this safety spark-gap is arranged inside the magneto and is not of such an elaborate character.

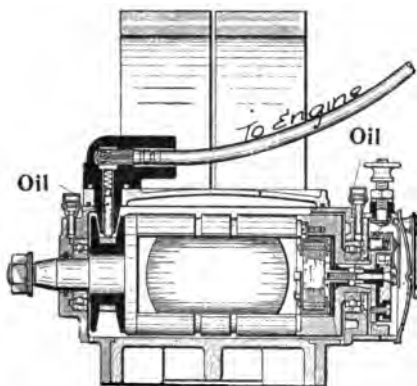


FIG. 47.—Bosch Magneto for Single-Cylinder Engine.

Figs. 47 and 48 show sections of single-cylinder and 4-cylinder magnetos. Fig. 48 should be studied in conjunction

with the diagrammatic representation in Fig. 44.

When dismantling the magneto for any purpose, or when

the magneto is taken off the car for cleaning or repairs, great care should be taken to see that everything is put

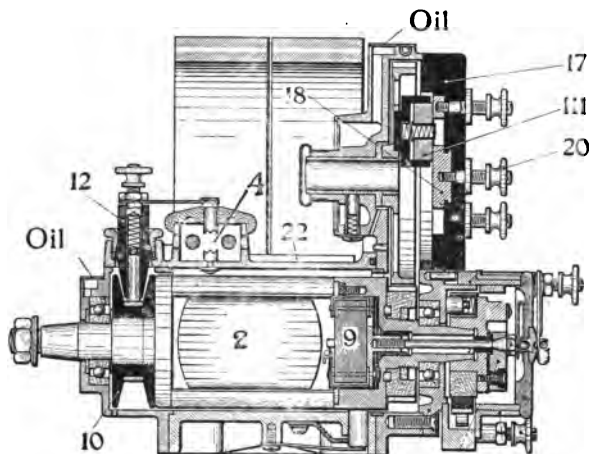


FIG. 48.—Section of Magneto.

- | | |
|--|------------------------------------|
| 2. Rotating primary and secondary coil. | 17. Distributor disc. |
| 4. Safety spark gap. | 18. Centre distributor contact. |
| 9. Condenser. | 20. Cable terminal from coil. |
| 10. Slip ring. | 22. Dust Cover. |
| 12. Collector carbon-holder with nut for cable connection. | 11. Distributor carbon and spring. |

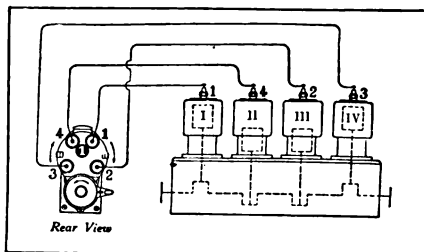


FIG. 49.

back as taken off. Fig. 49 shows the wiring between the magneto and the sparking plugs for an engine which fires in the order 1, 3, 4, 2.

Double Ignition.—Many of the more expensive cars have the ignition in duplicate. This may be in the form of two quite distinct installations, accumulator and coil and magneto, each having its own distributor and its own set of sparking plugs ; or it may be in the form of " dual " ignition, in which the ignition sets are partly in duplicate—that is, there is an accumulator and coil and a magneto ; but both of these in the dual system use the same distributor and the same set of plugs. The latter method is by far the more common, as it is simpler, lighter, and cheaper. The original idea of the two sets of ignition was to provide an emergency set in case the other went wrong ; but this reason no longer holds, because the magneto has been perfected to such an extent that it is very seldom indeed that a magneto which is properly looked after is at fault.

Starting Advantages.—One considerable advantage of having an accumulator and coil system as well as the magneto is that it is easier to start on the coil than on the magneto. The reason for this should be easily understood if the previous work has been studied carefully. The spark given by the magneto when it is being turned very slowly is feeble and is not hot enough to ignite the charge, due to the slow cutting of the lines of force by the primary, whereas the spark—or, rather, the series of sparks—given by the coil system is equally strong no matter what the engine speed may be ; or, for that matter, whether the engine is at rest. Another advantage of adding the coil system is the ease with which the engine often starts by simply switching on the current. For example : assume that the engine has been stopped by switching off and not by shutting off the mixture at the throttle, the cylinders will be filled with a suitable mixture for firing ; then, if too long a time has not elapsed, when the accumulator-and-coil ignition is switched on sparks will occur at one of the plugs, and that cylinder will fire and so start the engine. It should be noted that the spark should be fully retarded before switching on, or there is a chance that the piston may have come to rest just before the top of the compression stroke, in which position with an advanced spark the engine would be reversed and a backfire might occur. The latest

Dual System of Ignition.—Fig. 50 shows the application of "dual" ignition to a car. It will be seen in the figure that an accumulator and coil are supplied as well as

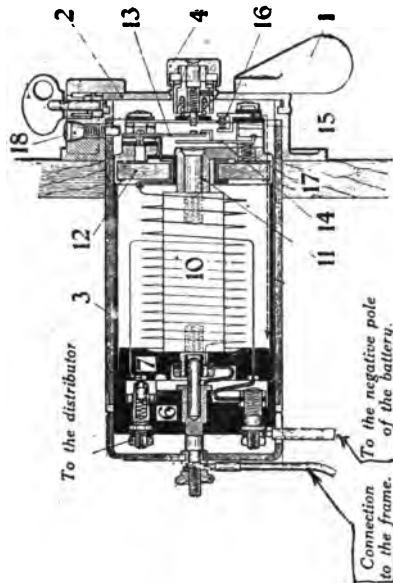
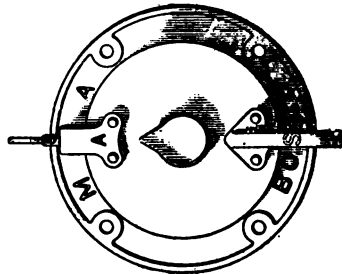


FIG. 51.—Coil for Dual Ignition.

- 10. Iron core.
- 11. Plate carrying the starting arrangement and the condenser.
- 12. Condenser.
- 13. Contact spring.
- 14. Trembler.
- 15. Auxiliary contact breaker.
- 16. Trembler spring.



- 1. Switch handle.
- 2. Coil case.
- 3. Starting press button.
- 4. Fixed connection plate.
- 7. Movable switch plate.

a magneto. The coil is a comparatively small and light affair, and fits neatly into the dashboard, taking up little room. The magneto distributor is used for both systems, being connected by means of wires to the coil-box terminals.

Fig. 51 shows details of the coil itself. By pressing on the button (4) the platinum points are brought into contact and the trembler commences to act, thus firing the charge and starting the engine. Should there not be any gas in the cylinder concerned, or should the mixture be either too weak or too strong to ignite, the engine must be started in the usual way by means of the starting-handle.

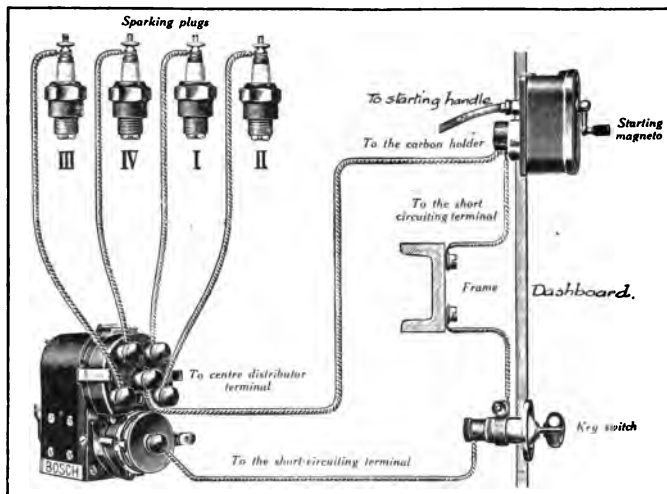


FIG. 52.—Bosch Starting Magneto.

Fig. 52 shows another arrangement to assist in easy starting. A small auxiliary magneto called a starting magneto is fastened to the dashboard and connected up by means of a flexible shaft to the starting handle, the speed of rotation being increased by means of a chain drive. In this way, although the main magneto may be going too slowly to give a hot spark, the starting magneto supplies the necessary spark, and when the engine fires the main magneto takes up the work. If the engine cylinders happen to have a charge of combustible mixture in them, then to start the engine the small handle on the starting magneto is turned, and a succession of sparks will be generated in the proper cylinder. This is similar to "starting on the switch" in

dual ignition, and does away with the necessity for accumulators.

Fig. 53 shows the latest pattern of Bosch waterproof magneto.

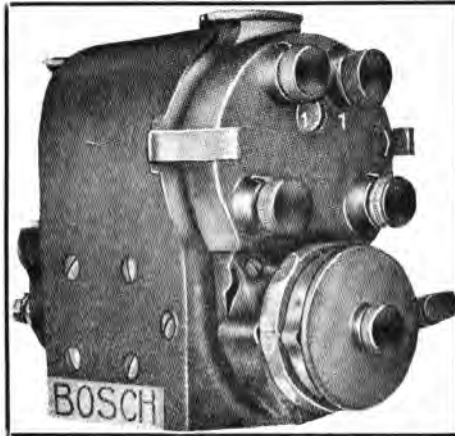


FIG. 53.—Bosch Magneto. Waterproof Pattern.

CHAPTER VIII

CLUTCHES

The Clutch.—Directly behind the engine, and usually in the internal space inside the flywheel rim, is the clutch. This is the mechanism by which the connection is made between the engine at the front of a car and the gear box, from which the drive is carried through the propeller shaft and differential to the road wheels at the back of a car. Its particular functions are to allow of the engine being run without any other part being in motion (as when the driver puts the gear in when starting), to aid in quiet and efficient gear changing, and by slipping to permit the drive to be taken up without shock. If a clutch did not allow of a certain amount of slipping when starting a car, so giving a gradual increase of speed, the occupants would be subjected to a nasty jar, and the gear wheels, shafts, and other transmission mechanism of the car would be liable to be damaged from the severe shocks. Tyres would also wear more rapidly, due to the clawing action between the tyre and the ground when starting. A good clutch should be simple ; it should be of light construction, in order that it may come to rest rapidly ; few adjustments should be required ; and a small movement of the actuating levers should be sufficient to free the engaging surfaces. It is desirable that it should be self-contained, and that there should be no possibility of its getting out of line.

Types of Clutches.—There are four main types of clutches : (1) The cone clutch ; (2) the expanding clutch ; (3) the single-plate clutch ; (4) the multiple-disc clutch. There are several variations in each of these types, most makers of cars having a distinctive method of setting up the clutch and its actuating pedals.

Friction discs, especially in light cars, are also coming into use, and where the power to be transmitted is low and in designs in which the friction plates can be easily renewed when worn they give very good results. Their special advantage is that they render a gear box unnecessary and so cheapen construction.

The Cone Clutch.—The cone clutch is the oldest, simplest, and cheapest form of clutch, and consists of a coned external surface on an inner sliding member which fits into a machined part on the interior of the flywheel rim, the angle of taper being in each case about fifteen degrees. The surface of the sliding cone is covered with leather, and springs are usually placed at intervals round the clutch, under the leather, in order that the drive may be taken up smoothly. When fully engaged, the pressure between the engaging surfaces is sufficient to press these springs into recesses and so put them out of action.

Clutch Spring.—Under normal conditions a powerful spring, usually concentric with the central shaft, keeps the clutch surfaces in gear; and when it is desired to have the engine running free a pedal is pressed by the foot, which draws out the internal engaging surface by compressing the spring still further. One end of the spring bears directly on the cone, the reaction at other end being taken up against a ball bearing which allows the spring to go round with the clutch without too much friction. It is important that the whole of the sliding part of the clutch should be carried on an extension of the crank shaft, to which the flywheel is bolted, in order that it may remain concentric—that is, in line. Fig. 54 shows a cone clutch of this type, the sliding cone being carried as stated, and the thrust at the back end of the spring being taken up by a ball-bearing washer which can be adjusted by means of the lock nuts behind it, thus adjusting the compression of the spring. This ball bearing reduces the friction when the clutch is

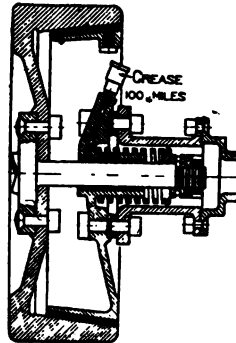


FIG. 54.

disengaged, but is not acting as a bearing when the clutch is engaged, the whole arrangement going round as one solid piece. A point worth noting in this clutch is the method of bolting the driving housing which takes the drive to the gear box, springs being inserted between the clutch and the housing. Thus, if the gear box by any mischance gets out of line there is not the same tendency to twist the cone.

Internal Cone Clutch.—This clutch (Fig. 55) is similar to the last type, but acts in the opposite direction.

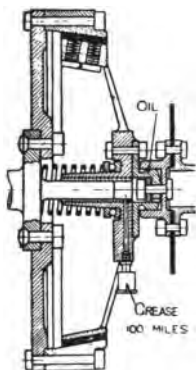


FIG. 55.

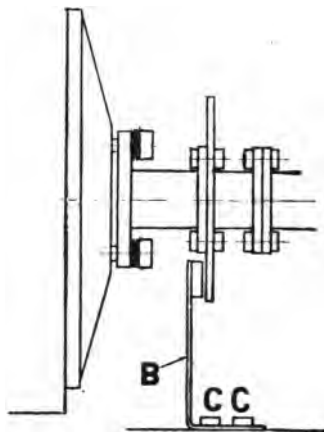


FIG. 56.

The rim of the flywheel is separate and bolted direct to a large plate fixed to the end of the crankshaft. There is no chance of this type of clutch getting out of line. The end of the spring, as in the last case, rests on a ball bearing to reduce friction when the flywheel part is rotating with the engine and the sliding coned part at rest. The lock nuts on the end of the crank shaft are not required in this case. When a clutch of the cone type is fairly heavy it has considerable rotational momentum, and some time elapses before it slows, thus prolonging the time required to make a change of gear. In order to slow the clutch more rapidly a small brake is sometimes fitted. The disc for this is shown in Fig. 55, and the details of the whole arrangement in Fig. 56, the

disc rubbing on the leather-faced pad B when the clutch is withdrawn.

Disadvantages.—The cone type of clutch has certain disadvantages. Unless the leather is attended to frequently and dressed with oil the clutch has a tendency to become fierce. The pressure between the leather and metal face has a limit, and therefore for high powers it requires to be very large. Unfortunately the flywheel diameter cannot exceed a certain measurement, so that unless large pressures between the surfaces are used there is a limit to the power it can transmit. When the pressures are too great trouble will occur, due to the rapid destruction of the leather. Also, if this type of clutch is slipped too much, the leather becomes burnt and useless.

Expanding Clutch.—The second type of clutch is the internal expanding metal-to-metal clutch, in which

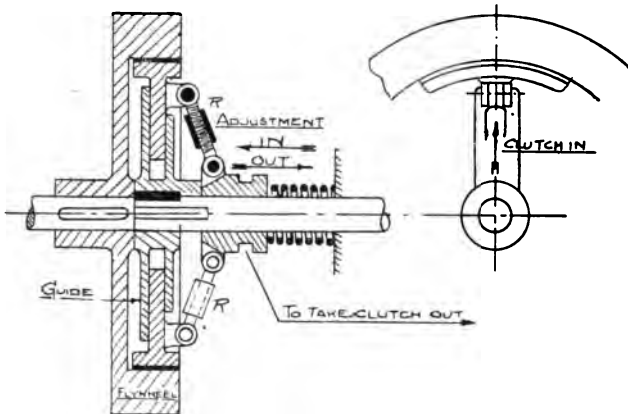


FIG. 57.—Expanding Clutch.

cylindrically-shaped external pieces are made to move out radially and engage with an internal cylindrical surface inside the flywheel. The adjustment of this type of clutch must be very accurate. Fig. 57 shows diagrammatically the general principles of the clutch. The spring presses forward the lower end of the adjustable rods R R, thus moving the other end outwards and so bringing the clutch

shoe—which is guided radially—against the inside of the flywheel. To take the clutch out of action the lower ends of rods R are pulled back by a fork in the slot shown against the pressure of the spring. Due to the accuracy of adjustment required and to the difficulties in the design this type of clutch is not much used.

Single-Plate Clutch.—A much more popular type of clutch is the single-plate clutch as shown in Fig. 58, in

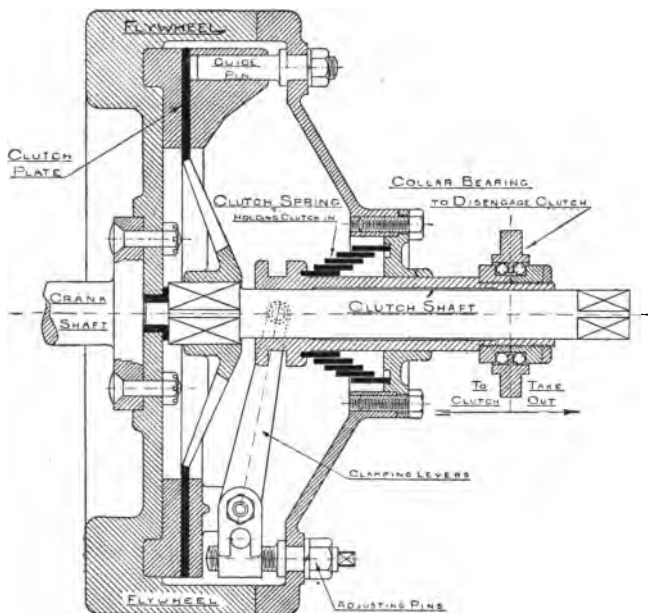


FIG. 58.—Single-Plate Clutch.

which a single flat circular plate is gripped between the inside face of the flywheel and a clamping plate which is made to grip the clutch plate by means of clamping levers actuated by a strong spring. The amount of pressure put on the clamping plate can be varied by adjusting the pins on which the end of the clamping levers pivot. To take the clutch out in this, as in nearly all types of clutches, the pedal at the driver's foot is made to compress the clutch

spring, pull back the inner end of clamping levers, and so release the clutch plate, which is then free from the engine. This clutch runs in a bath of oil, which prevents the plates' gripping too fiercely ; and, due to the fact that it takes an appreciable amount of time for the oil to be squeezed out

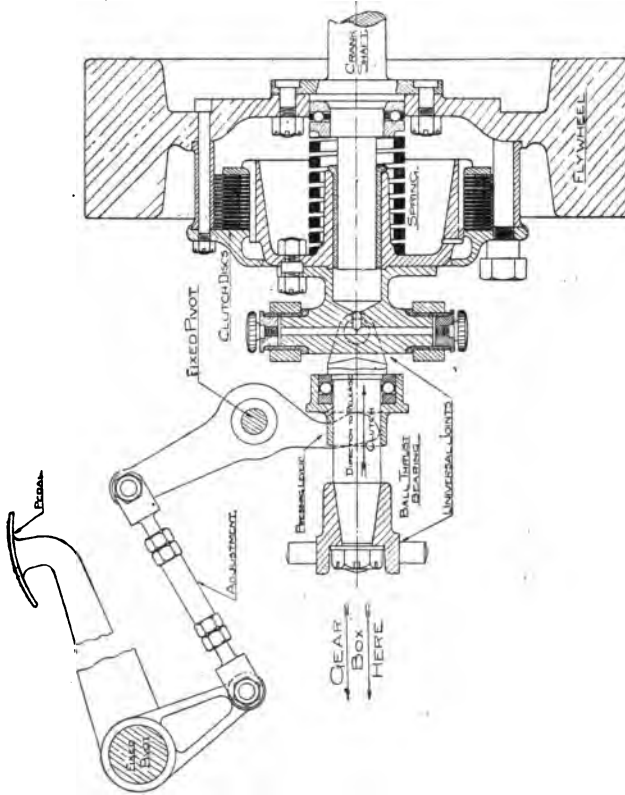


FIG. 59.—Multiple-Disc Clutch.

from between the plates, it takes up the drive sweetly and without shock.

Multiple-Disc Clutch.—For high powers the best clutch is probably of the multiple-disc type, which also has the advantage of being a particularly sweet clutch in

taking up the drive. This consists essentially of a large number of plates, one half of which are fixed to and go round with the flywheel or casing, the other half being fixed to the shaft going back to the gear box. These plates are placed alternately along the axis of the shaft (see Fig. 59)—first a shaft plate, then a flywheel plate, and so on. Although fixed as far as the rotation is concerned by the keys which engage with the spaces on the plates shown in Fig. 60, all the plates are free to slide longitudinally along these keys. When the clutch is in action the strong spiral spring presses all the plates together, and so the whole arrangement of flywheel plates, shaft, etc., goes round solidly as one mass; and when it is required

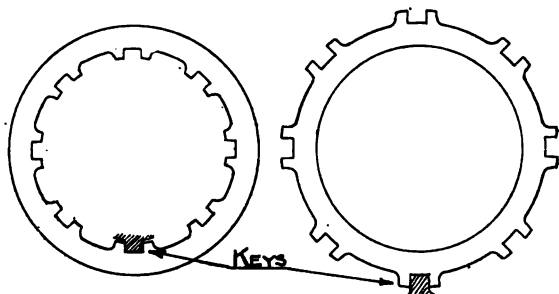


FIG. 60.—Internal and External Plates for Multiple-Disc Clutch.

to disengage the clutch the toe of the pressing lever, actuated as shown in Fig. 59 by the pedal at the driver's foot, compresses this spring still further and so releases the plates. Due to the large number of plates, the power transmitted may be considerable; and due to the viscosity or thickness of the oil preventing it being squeezed out too rapidly from between the plates when pressed together, the drive is taken up very smoothly indeed. As in the single-disc type, the plates run in a bath of oil.

Hele-Shaw Clutch.—Fig. 61 shows a modification of the last type in which, in place of flat plates, the engaging plates are V-shaped, the object being to gain more efficient engaging between the plates and to strengthen them and so prevent buckling. As in the multiple-disc clutch, one

half of the plates are attached to an outer casing which is bolted to the flywheel, the other half being attached to the inner casing, which revolves with the transmission shaft. Due to the tendency of the V grooves to stick together even

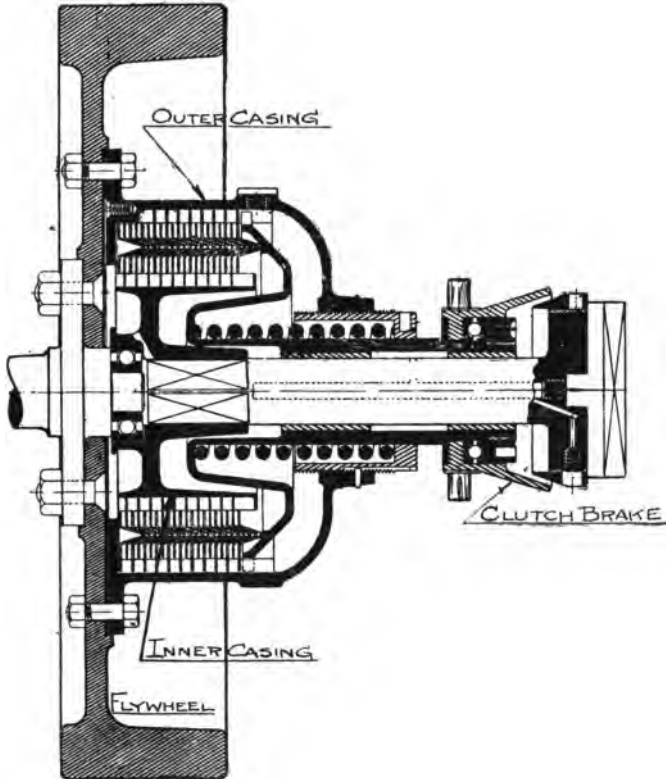


FIG. 61.—Hele-Shaw Clutch.

when the clutch spring is put out of action by the clutch pedal, small flat springs are fitted between each pair of discs in the Hele-Shaw clutch to separate the plates. In plate clutches of every form there is always a slight drag, due to the sticky qualities of the oil between the plates,

which tends to keep the clutch shaft revolving, even when the clutch is out of gear ; to stop this a clutch brake must

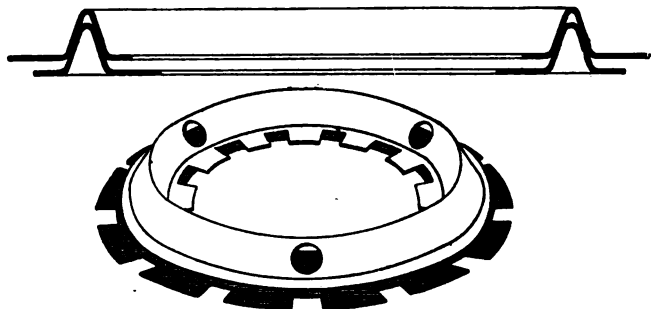


FIG. 62.—Two Views of Discs in Contact.

be fitted, a cone type being shown in Fig. 61. Fig. 62 shows two views of the discs in contact and the section of the V.

CHAPTER IX

THE GEAR BOX

The Gear Box.—Immediately behind the clutch—sometimes housed in the same chamber, but oftener connected up to it by means of a short shaft, as shown in Fig. 63—is

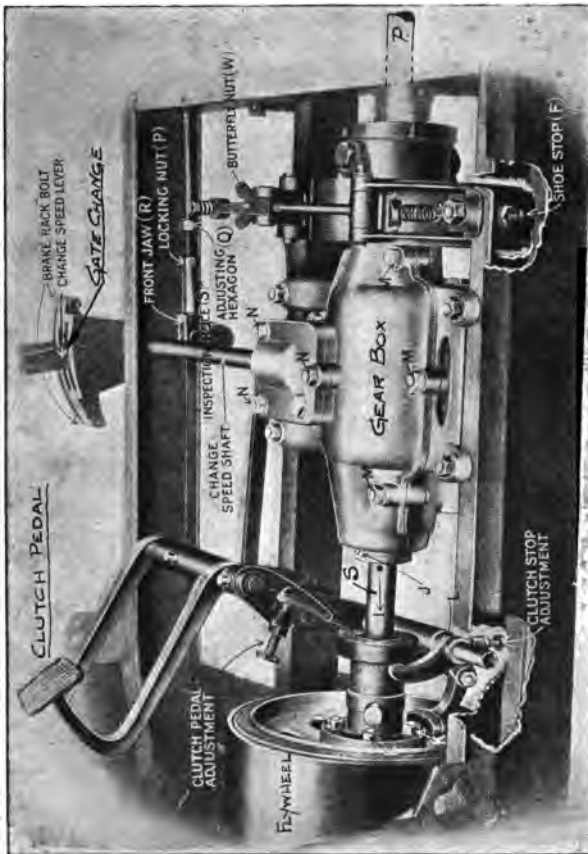


FIG. 63.—Clutch, Gear Box, Brake, etc.

the gear box. A motor-car engine rotates at a much higher speed than the back or driving wheels of the car, and in order to develop its full power it must continue to run at its top speed irrespective of the speed of the car. For example, on the level at 30 miles per hour the engine would probably be running at 1200 revolutions per minute, whilst the back or driving wheels would be rotating only at about 300 revolutions per minute—a reduction of 4 to 1. When climbing a very stiff hill the engine would still run at 1200 revolutions per minute, whilst the back axle would be turning round at about 100 revolutions per minute, giving the much greater reduction of 12 to 1. This variation of the ratio of engine speed to road-wheel speed is partly obtained in the gear box. The necessary reverse gearing for making the car run backwards while the engine and clutch still rotate in the same direction as before is also arranged for in the gear box.

Gear Wheels.—Before studying the arrangement of wheels giving the desired changes of speed it will be necessary to go into the question of gear wheels generally. Any pair of gear wheels when in gear consists of one short plain cylindrical roller rolling on another; and in order to prevent any slip between the two rollers, projections having a certain definite mathematical shape are made on one roller, these engaging with recesses of a corresponding shape on the other roller. These projecting parts and recesses are called teeth. When the shafts are parallel the wheels are called spur wheels, the smaller ones being called spur pinions; and when the shafts to be connected up are at right angles the wheels are called bevel wheels and pinions.

Speed Reduction.—In Fig. 64, assume that the top wheel A, which has 30 teeth, is going round at 120 revolutions per minute, then if the wheel B in gear with A has 60 teeth it will rotate at half the speed, thus reducing the rotating motion in the ratio of 2 to 1. It should also be noted that wheel B rotates in the opposite direction to wheel A. If these two wheels are separated so that their teeth are out of gear and a third wheel R (Fig. 64) made to gear with both, the wheel B will rotate in the same direction as wheel A, the relative speeds of rotation of A and B remaining the same, irrespective of the number of teeth

in R. Wheel R is often termed an idle wheel. The same effect can be gained by moving wheel B sideways out of gear with A and connecting the two together by a very long wheel R (Fig. 65). In this case the shafts of A and B

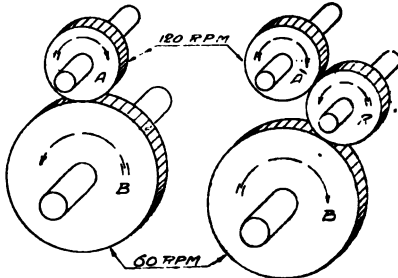


FIG. 64.—Gear Wheels.

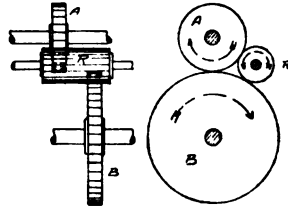


FIG. 65.—Reverse.

do not require to be separated. This arrangement is often used for the reverse motion in the gear box of a car.

Number of Speeds.—The tendency in modern cars is to have four forward speeds and a reverse, but in order to simplify the explanation a three-speed gear box is shown and described. In Fig. 66, S is the shaft coming from the

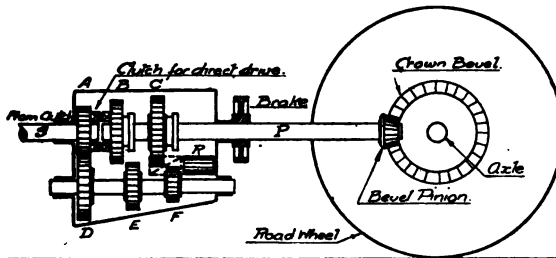


FIG. 66.—Diagrammatic Gear Box in "Neutral."

clutch. It enters the gear box, and just inside a spur wheel (A) is keyed to it. Just beyond the wheel this shaft ends. On the face of A there are projections which engage with projections on the face of a sliding wheel (B) keyed to the propeller shaft P, the centre line of which is continuous with that of shaft S.

Direct Drive.—When wheel B is slid close to A the projections—or clutch paws—on the two wheels engage with one another and the drive from S is taken directly through the clutches on wheels A and B to the propeller shaft P. This is termed the direct drive, as the whole arrangement is locked up solid by the clutches, and propeller shaft P travels with clutch shaft S at engine speed. In the direct drive any reduction required from the speed of engine to that of the road wheels must be made by the bevels at the back axle. The diagrammatic Fig. 66 shows the gears in neutral: that is, none of the gears are engaged; but the dotted square with the cross shows the position of the reverse pinion R when slid into gear. Fig. 67 shows the direct drive or third speed in gear.

Drive through the Lay Shaft.—Keyed to a second short shaft, called the lay shaft, there is a spur wheel (D),

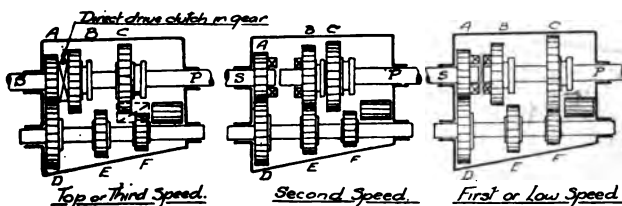


FIG. 67.

FIG. 68.

FIG. 69.

which is always engaged with A. When the gear is neutral, or when the direct drive is in, this wheel (D), together with the lay shaft, is simply rotating idly in space. To get a lower gear, wheel B slides along till it engages with wheel E, which is keyed to the lay shaft, as in Fig. 68. The drive is now from shaft S through A to D along the lay shaft to the wheel E, and so through to B on shaft P. Wheel D being a little larger than A, the lay shaft is rotating more slowly than shaft S; and as B is larger than E the shaft P is running still slower, so giving a larger ratio for the speed of the engine to that of the road wheels. When the first or slowest speed is desired wheel C is slid along till it comes into gear with F, the other wheels (B and E) being out of gear; and as C is still larger than B, and F smaller than E the reduction of speed from shaft S to shaft P is further accentuated.

The Reverse.—Fig. 69 shows the first speed in operation ; and, as explained before, to obtain the reverse motion—that is, to make shaft P rotate in an opposite direction to shaft S—the idle wheel R is slid along its own shaft till it gears with both C and F, as shown by its dotted position in Fig. 66. Note that for forward running A turns D, and therefore E and F, in the opposite direction to the shaft S ; and E gearing with B or F with C reverses this again and brings back the direction of rotation to the same

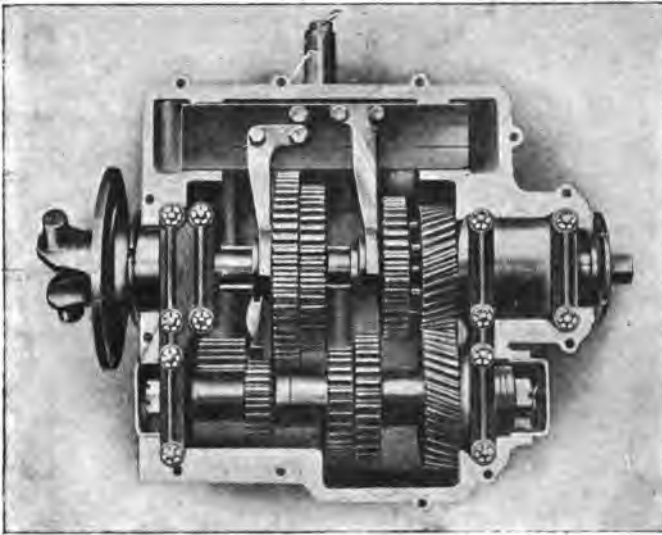


FIG. 70.—Arrol-Johnston Gear Box.

as it was before—that is, the same as S. When the idle wheel R is put into gear with wheels C and F, C F not being directly in gear, the wheel C, as explained by Figs. 64 and 65, rotates in the same direction as F—that is, the same as D and opposite to shaft S—thus reversing all the rotating motions of shaft P, the back axle, and the road wheels, and so running the car backwards. Sometimes a fourth wheel on the lay axle is used which is always in gear with R, and the wheel C is then moved along to also gear with R, so giving the reverse motion in another way. There are a

great many designs for gear boxes, giving the changes of gears by different methods, but by far the largest percentage of these are of the sliding type which has just been explained. If the above has been thoroughly digested a little study will soon enable the motorist to follow the method of gear changing in any sliding-type gear box.

Fig. 70 shows a pictorial drawing of the four-speed Arrol-Johnston gear box, the engine being at the opposite end to that shown in the diagrammatic drawings. The clutch teeth for the direct drive are seen, and the levers for sliding the wheels along the propeller shaft to their various positions are shown. In the left-hand bottom corner is the reverse-motion pinion. In order to make the drive less noisy the first pair of wheels, corresponding to A and D in the sketches 66 to 69, are made with helical or sloping teeth. At the left-hand end of the gear box is shown the universal connection for the propeller shaft. All the bearings in a gear box—and, in fact, almost everywhere on a car, except in the engine—are ball bearings.

Quadrant Gear Change.—The shifting of the proper wheels into gear in the gear box is done by the driver of the car by means of a lever at his side. In the early days one back and forward movement of the lever gave the three speeds, a neutral position, and a reverse position, a spring forcing a projecting piece into a notch as shown in Fig. 71. To shift the gear—that is, to alter the gear ratio—the projecting piece was lifted out against the pressure of the spring and the lever slid along to the next position, in which it engaged, and so on. This form of gear-changing lever gave considerable trouble, as the driver was liable to make a mistake and either overrun the proper notch or make a mistake as to which notch his lever was in.

Gate Change.—The almost universal method now used is to combine a back and forward movement with a side movement, through an opening in the centre of the quadrant called the gate, as shown in Fig. 72. In a three-speed gear box the reverse and the first speed are opposite each other in the same compartment, the second and top speeds being in the adjoining compartment. In order to prevent any possibility of putting the gear in reverse by mistake,

when shifting from first speed through the gate to second speed, there is an interfering projection which prevents the reverse being engaged until the trigger at the top of the handle has been pressed down. The action at the bottom of the gear lever varies with different cars ; but in

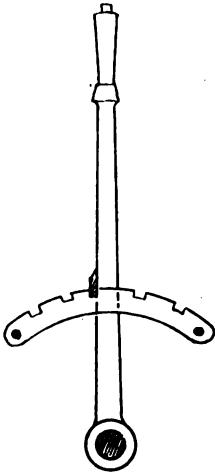


FIG. 71.—Quadrant.

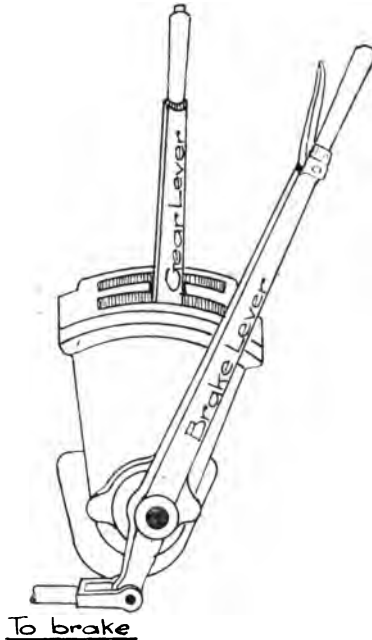


FIG. 72.—Gate Change.

general when the lever is through the gate to the right it actuates a cross-lever going into the gear box, giving two changes ; and when through the gate to the left it actuates an entirely different cross-lever, giving other two changes in the gear box. Fig. 73 gives a general view of the Deasy gear box, the arrangement having two gates, giving four forward speeds and a reverse. It should be noted particularly that when changing from one gear to another the lever must always pass through a central position in line with the gate, in which the gears are in neutral, thus

preventing the possibility of two different speeds being in gear at the same time.

Brakes.—Alongside the gear lever, and working on a

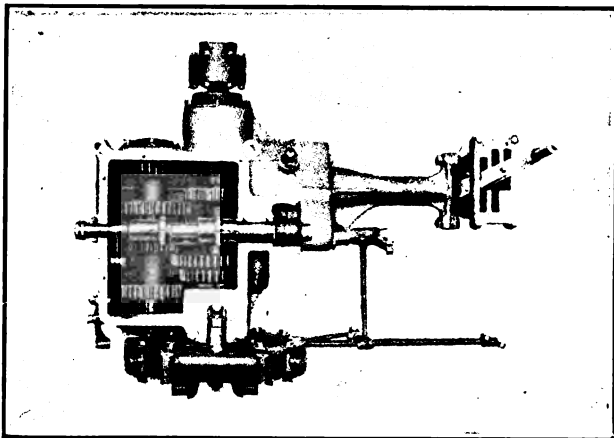


FIG. 73.—Gear Control.

parallel quadrant, is a brake lever which works the brakes on the back wheels. Immediately behind the gear box there is also a brake. The principles underlying the action of the brakes will be dealt with later.

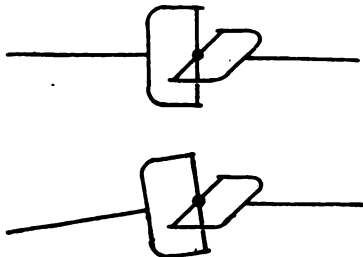


FIG. 74.—Universal Joint.

Universal Joints.—

The shaft carrying the drive from the back end of the gear box to the back axle cannot be a rigid one, because the movement of the gear box — which is attached to the frame — and the movement of the back

axle are quite different. The motion of the back axle, on which the springs are resting, is of the nature of a violent vibration, as the wheels meet the inequalities of the road ; whereas the chassis or frame, being mounted on the top of

the springs, has a fairly smooth, even motion, the object of the springs being to damp or soften the jumping motion of the wheels. It will be seen, therefore, that flexible joints must be introduced between the gear box and back axle. These joints are called universal joints, as the driving shaft



FIG. 75.—Universal Joint.

can be out of line in any direction without interfering with the transmission of the rotation from gear box to back axle. Fig. 74 shows diagrammatically the general principle of the joint, and Fig. 75 shows the actual joint in practice. The drive from the gear box is thus carried through the propeller shaft to the back axle.

CHAPTER X

THE DIFFERENTIAL

Differentials.—The transmission of the power has been traced from the engine through the clutch to the gear box, in which the rate of transmission can be varied; then

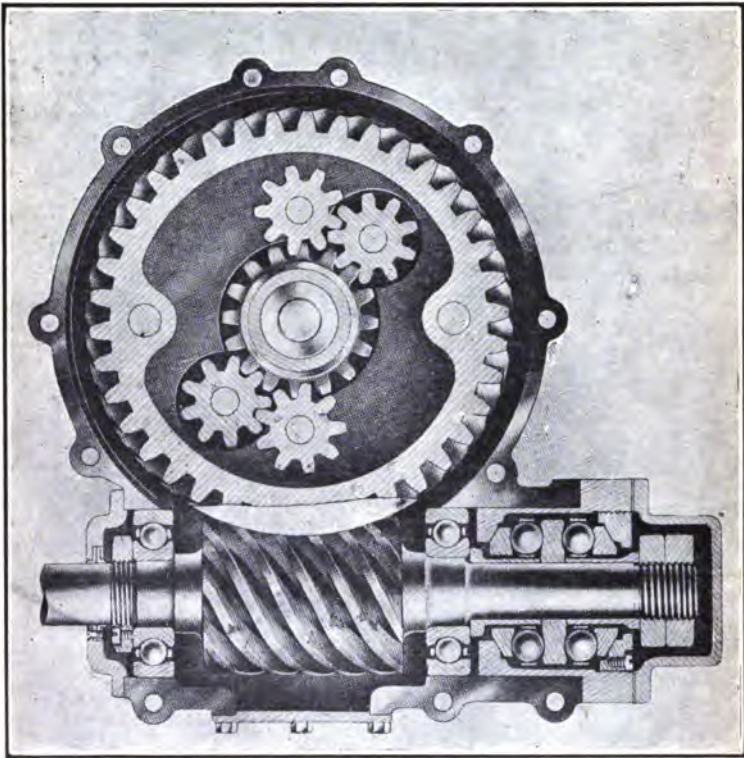


FIG. 76.

through the universal-jointed propeller shaft to the right-angled drive at the back axle. There are two methods by which the longitudinal rotation of the propeller shaft may be converted into the cross rotation of the back axle, namely, by means of bevel wheels or by means of worm and worm wheel.

Fig. 76 shows the worm and worm wheel arrangement, and Fig. 77 shows a bevel arrangement. The small bevel is called the bevel pinion and the large one the crown bevel. In the worm drive there is a very large end-thrust along the worm shaft, and powerful end-thrust ball bearings have to be used as well as the usual running ball bearings.

In order to make the action of the differential as clear as possible, it will be necessary to study what is happening at the road wheels under various circumstances.

Fig. 78 shows the path of a car along a straight road.

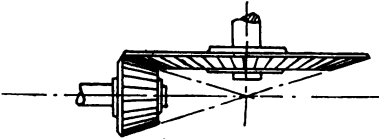


FIG. 77.—Bevel Wheels.

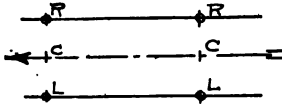


FIG. 78.

RR is the distance travelled by the right-hand wheel in any given time, say one second ; LL the distance travelled by the left-hand wheel in the same time ; and CC the distance travelled by a point midway between two wheels, which as they have to roll over the same distance rotate at equal speeds.

Fig. 79 shows a method of driving the axle which would be quite efficient while the car was running along this straight line. The crown bevel is keyed to the axle near the centre and the wheels R and L are keyed to the ends. As the propeller shaft rotates the pinion drives the bevel wheel which turns the axle ; the bevel, axle, and road wheels going round solidly together. The car, however, must be capable of turning corners, therefore what is happening to the wheels when doing so must be considered. In Fig. 80 the central point travels the same distance as before (CC), but it can be seen that the distance LL travelled by the

inner or left-hand wheel is less than CC , and the distance RR covered by the right-hand wheel is greater than CC .

If the wheels L and R are rigidly connected, as in the last case, they must rotate at the same speeds; but if the wheels are to roll, and not drag, they must rotate at different speeds, since the distances LL and RR are different. A moment's thought will show that the wheels cannot be allowed to drag, as the amount of rubber worn off the tyres (each of which is carrying a load of nearly half a ton) in turning even one corner would be considerable. For this reason each wheel must be free to rotate at its own speed.

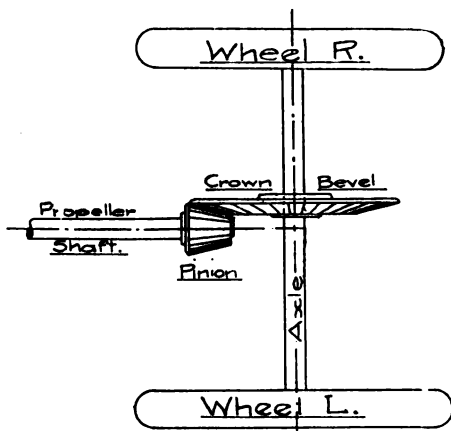


FIG. 79.

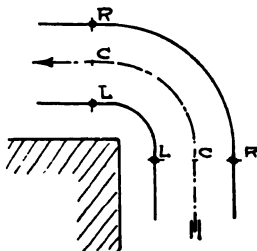


FIG. 80.

Also, due to this dragging action, steering would become very difficult: so much so that corners could not be turned by the ordinary driver with safety at any considerable speed.

Before going farther it should be noted that the extra distance travelled by R over the distance travelled by C is exactly equal to the difference between the travels of C and L : therefore R gains exactly the same number of revolutions that L loses in any given time.

For correct running wheel R must be free to run at a different speed from wheel L , and the mechanism which permits of this being done is called a difference mechanism

or differential. The diagrammatic sketches (Figs. 81) show the development of this. Fig. 81*a* shows the road wheels as in Fig. 79; but it should be noted that whilst the wheels are fixed to the axle, the axle is divided at the centre and on each part a smaller bevel wheel is fixed. For straight-line driving the two bevels must be taken round together at the same speed, and this is done by connecting them by the bevel pinion P as in 81*b*, which connects up the two parts of the axle, the whole arrangement turning solidly as in Fig. 79. The crown bevel in this case, instead of being attached to the axle, is attached to the bevel pinion P, as shown in Figs. 81*b* and 82, and in revolving it pulls the bevel pinion round with it, thus driving the road wheels through the inner bevel wheels as shown in Fig. 81*b*. In place of transmitting the drive through one bevel pinion, as in 81*b*, usually three or four are placed at intervals round the circle, thus strengthening the drive.

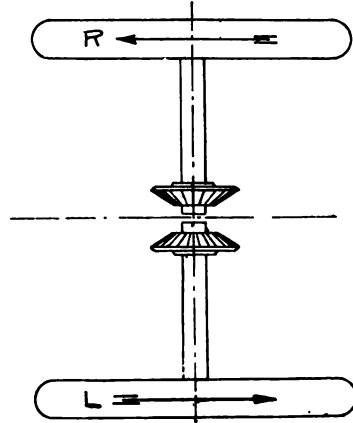
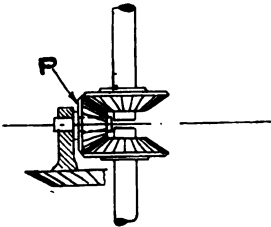
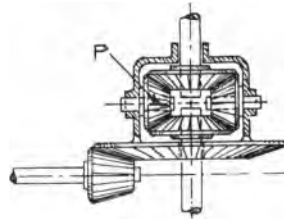
FIG. 81*a*.FIG. 81*b*.

FIG. 82.

Reverting to Fig. 81*a*, if the back wheels R and L are raised off the ground and wheel R turned in the direction shown by the arrow, then this motion must be transmitted through the bevels, and wheel L will rotate at the same

speed but in the opposite direction. This is what happens

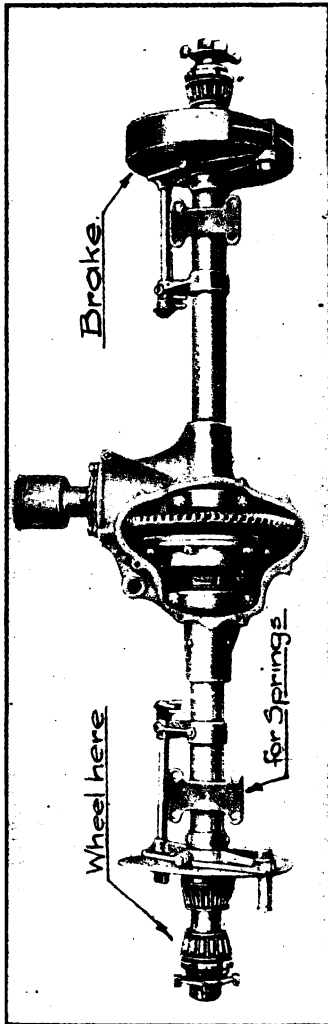


FIG. 83.—Rear Axle Bevel Drive.

when turning a corner. Just before reaching the corner, assume that R and L are rotating at 100 revolutions per minute, and that the centre of the car is travelling at 10 miles per hour. On reaching the corner R speeds up to 110 revolutions and L must slow down to 90 revolutions, the centre of the car travelling at the same speed as before. If the corner is a sharp right-angled one the difference in the speeds of the two wheels may be even greater; whereas if it be a gentle deviation from the straight, or a swerve outwards to pass a vehicle, the difference in the speeds of R and L will be very small. The whole object of the differential is to enable the drive to be transmitted from the propeller shaft to the road wheels and yet leave the latter free to vary in speed relative to each other.

Fig. 82 is a diagram showing the complete differential in its simplest form, and Figs. 83 and 84 show the actual application to a car of this bevel type. Another form

of differential is the parallel type, in which the inner or

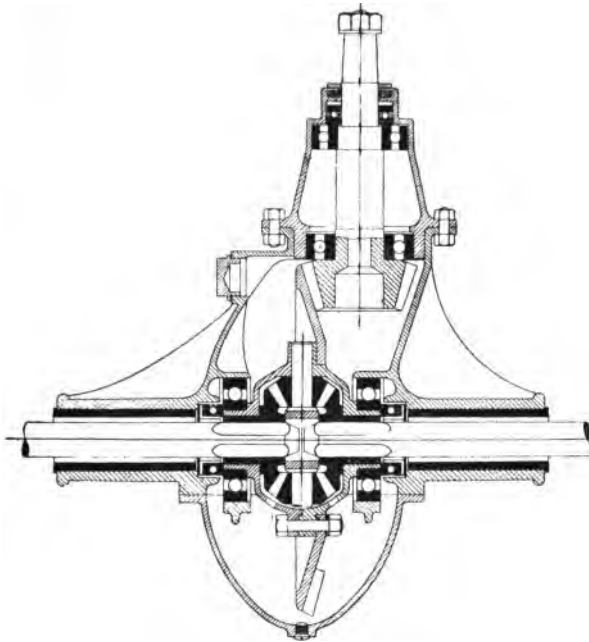


FIG. 84.—Bevel Differential Gear.

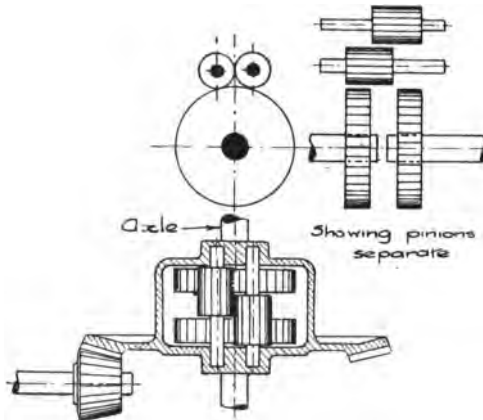


FIG. 85.—Parallel Differential.

differential wheels are spur wheels and pinions in place of bevels.

The principle is the same ; but in place of providing a single bevel pinion to connect up the two bevels keyed on

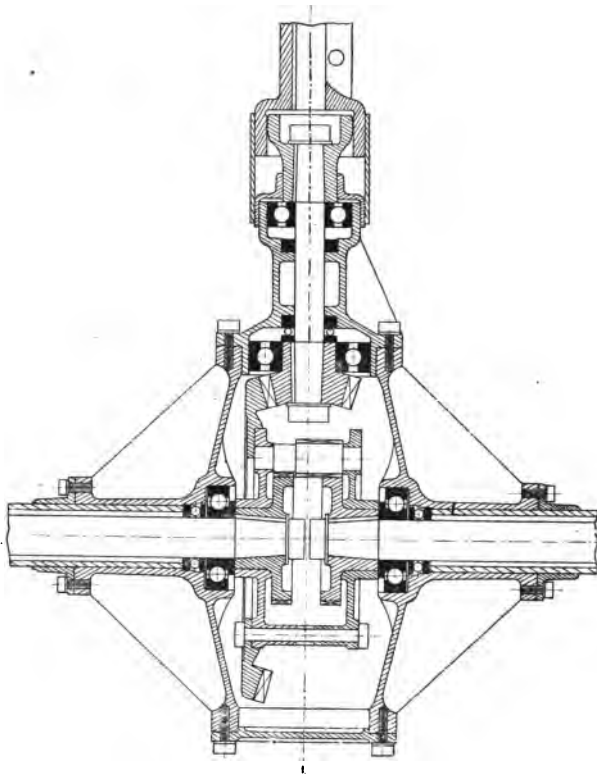


FIG. 86.—Parallel Differential Gear.

each half of the axle, two long spur pinions are used to connect up two spur wheels as shown in Fig. 85.

Each pinion only gears with its own wheel, but the projecting parts gear with each other. When on the straight the propeller shaft pinion turns the whole arrangement solidly as one piece, and when on a corner the extra

rotation of the right wheel R is transmitted as before through the spur pinions to the left-hand wheel (L), the two long spur pinions taking the place of and performing the same function as the small connecting bevel pinion in the bevel-type differential. Types of parallel differentials are shown in Figs. 76, 85, and 86.

Since the axle is broken in the centre to permit of the differential action, it cannot bear the weight of the body, wheels, etc., on it. Therefore it simply serves to transmit the turning movement or rotation to the wheels. A strong steel outer casing round the driving axle serves the same purpose as the axle in an ordinary carriage, carrying the

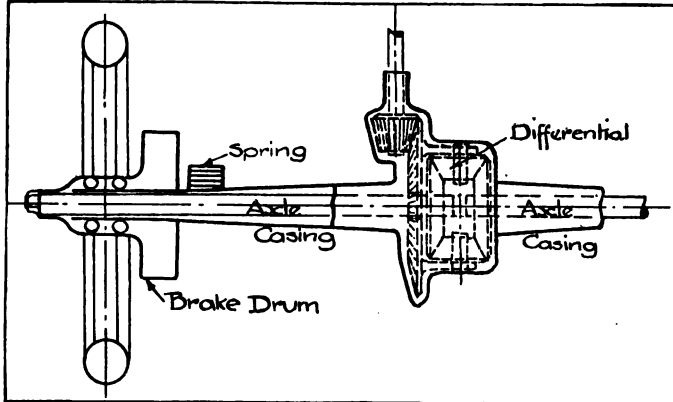


FIG. 87.—Back Axle Simplified.

weight of the body, passengers, etc., through the springs and transmitting it to the road wheels. This simply means that there are really two axles—a tubular one outside the solid one, the first carrying the weight and the second transmitting the drive.

The road wheels rotate on ball or roller bearings on this casing or stationary axle. Fig. 87 shows this diagrammatically. Attached to each back wheel is a brake drum on which an internally expanding strap acts, thus braking the car.

To prevent sudden shock on the springs and gear due to the reaction of the crown bevel—that is, to prevent the

turning tendency of the outer axle-casing when the drive is taken up—a torque rod connects up the casing to one of the cross members of the frame, which takes this thrust. Sometimes the propeller shaft runs inside a tube which serves the same purpose. Tie bars or radius rods similar to

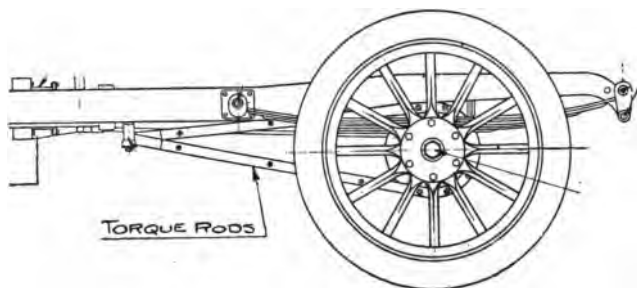


FIG. 88.

the torque rod are also used to assure rigidity and alignment. The torque rod of a 15 h.p. Standard car is shown in Fig. 88. As the whole weight of the back portion of the car is transferred through the springs to the outer axle or casing, one or more tie rods often are placed on the underside of this casing, thus strengthening it considerably.

CHAPTER XI

BEARINGS AND BRAKES

HAVING considered the transmission of the drive from the engine through the various shafts to the road wheels, it will be well to now consider how these shafts are supported. There are two types of bearings in general use, plain bearings and ball bearings, both types being used on a car.

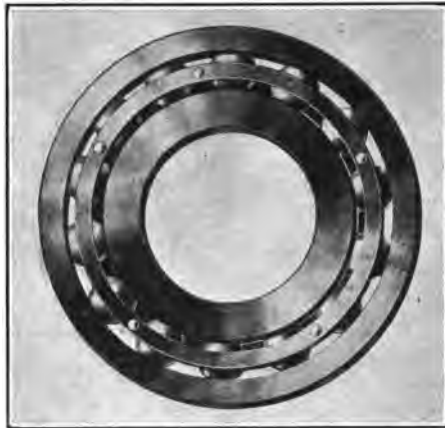


FIG. 89.—Ball Bearing.

Ball Bearings.—The amount of power lost in either plain bearings or in ball bearings is very small when the bearings are kept well lubricated ; but if plain bearings are neglected, or if for any reason the oil fails to lubricate them effectively, the friction increases very greatly, and if the fault is not remedied at an early stage the bearings become damaged. In ball bearings, however, all that is necessary

is to supply them with grease periodically, more to prevent the formation of rust than to reduce the friction. Ball bearings must be made of the finest materials, must be very accurate, and must not be overloaded.

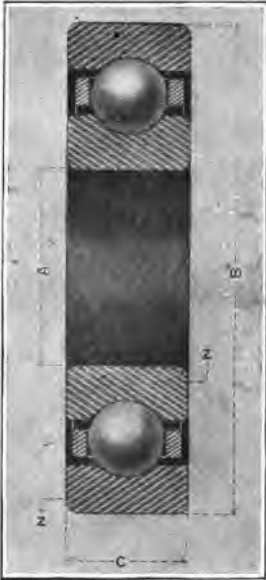


FIG. 90.

Experiments have shown that if the surfaces of the balls or of the race—or surface on which they run—are even slightly damaged the efficiency of the bearing falls off enormously. There are two main types of ball bearings—running bearings and end-thrust bearings. For every running bearing or series of running bearings on a shaft an end-thrust bearing must also be supplied.

Applications.—Fig. 89 shows a side view of a running bearing, showing the balls in a cage which keeps them at the proper distance from each other. Fig. 90 shows a section of this bearing, in which it is seen that the path or race in which the balls run has a curvature whose radius is only slightly greater than that of the ball.

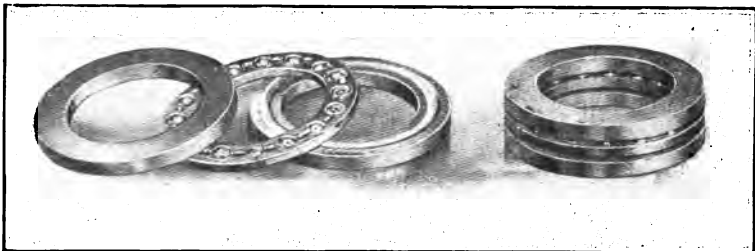


FIG. 91.—Ball Thrust Bearing.

The cage is also seen in this view. Fig. 91 shows the various parts of a thrust bearing, the balls again being held loosely

in a cage as before. Fig. 92 shows the application of both running bearings and thrust bearings to a gear box. Here the thrust bearings are small, because the end thrust is not severe ; but in Fig. 76, which shows the application of ball

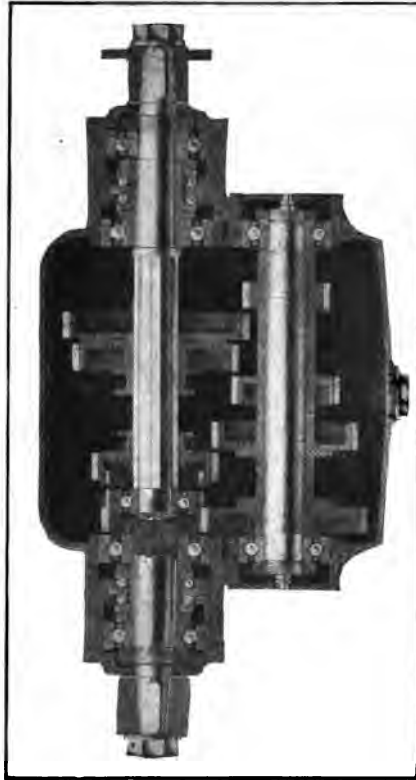


FIG. 92.—Application to Gear Box.

bearings to a worm-driven differential, the end thrust is very severe, and powerful thrust ball races are used.

Roller Bearings.—Where the pressures are high, rollers whose centre lines or axes lie parallel to the axis of the shaft may be used, and in place of one point taking the load it is taken by a line. A type of roller bearing which is

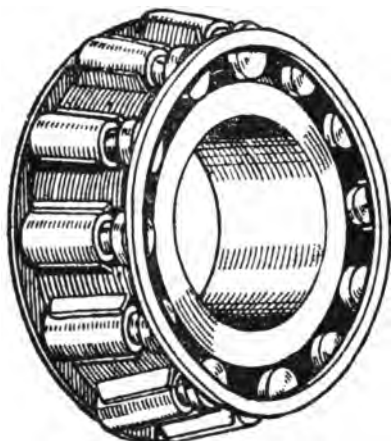


FIG. 93.—Roller Bearing.

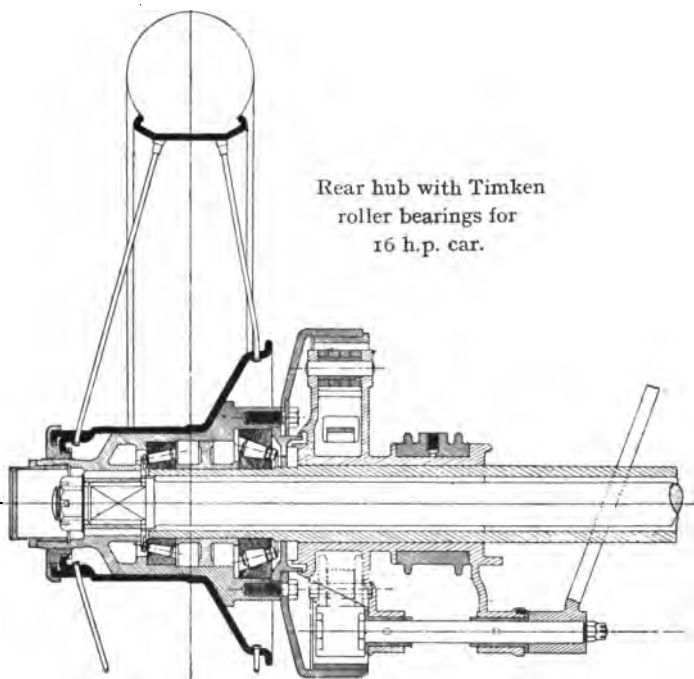


FIG. 94.

coming into use very rapidly is the conical roller bearing, in which the axes of the rollers lie on the surface of an imaginary cone, the rollers themselves being conical in form. This type of roller bearing, shown in Fig. 93, can take up a certain amount of end thrust, and so do away with the necessity for two separate bearings—running and thrust—on a shaft. Fig. 94 shows the application of roller bearings to the driving wheel of a car.

Brakes.—To bring a motor car to a stop after the power has been shut off, it is necessary to apply a brake. Brakes are also used to stop the car suddenly—say in order to avert an accident—and may be employed to vary the speed of a car when going through heavy traffic. Although they should be used as seldom as possible, and frequently quite a long time may pass during which they are but seldom used, they must always be ready on the instant to take up their full duty. Quite a large proportion of motor accidents are due to faulty or badly-adjusted brakes. It is necessary, therefore, that brakes should be powerful, easy to adjust, and be incapable of going out of effective action. In horse-drawn vehicles the horse is depended on for a considerable amount of braking action when going through traffic, the single brake used being in the form of a shoe rubbing on the iron tyre of the wheel. This type of brake could not be used for motor vehicles with their rubber tyres, as valuable rubber would be worn off at each application. Special drums or flat pulleys therefore have to be used in motor cars; and there must be two brakes, each of which must be capable of controlling and stopping the car, the second being considered as an emergency brake for use should the first go wrong.

Action of Brakes.—When a car is being driven, all the driving action takes place through the back wheels, which endeavour to push the road away from the car. And as the road is a fixture the car must travel along the road. In braking a car the opposite action takes place, because the brake tends to stop the back wheels from turning; and so these wheels are trying to pull the road towards the car. This will go on till the braking action is strong enough to stop the back wheels from rotating, when they will slide bodily along the ground. This should never

happen, because it severely punishes the tyres and because the braking action of wheels which have once begun to slide is less than when they are still going round. Another reason why the back wheels should not be locked is because the steering is affected and control of the car may be lost, thus increasing many times the chance of an accident.

Position.—One brake is worked by hand, the lever being at the driver's side; the other by a pedal at the driver's foot. The hand brake usually acts on two drums, one fixed to each back wheel (see Figs. 83, 87 and 94). The foot brake is applied to a drum fixed to the transmission shaft just behind the gear box. The clutch brake must not be confused with the brakes for stopping the car, its only duty being to slow the revolutions of the clutch and so facilitate the changing of gear.

Forms of Brakes.—Motor car brakes usually consist of a steel drum, on the outside or inside of which contracting

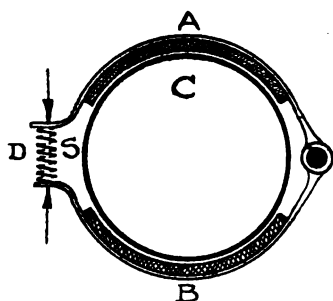


FIG. 95a.

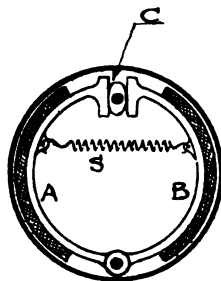


FIG. 95b.

or expanding pieces are made to rub. In a few cases there is an external or contracting piece on the outside and an internal or expanding piece on the inside of the same drum, in which case the brakes are always on the back wheels of the car. Fig. 95a and Fig. 95b show diagrammatically these two types of brakes. In Fig. 95a the two external pieces A B are made to rub on the drum C by closing up the space D as shown by the arrows, and in Fig. 95b the pieces A B are made to rub inside the drum by means of

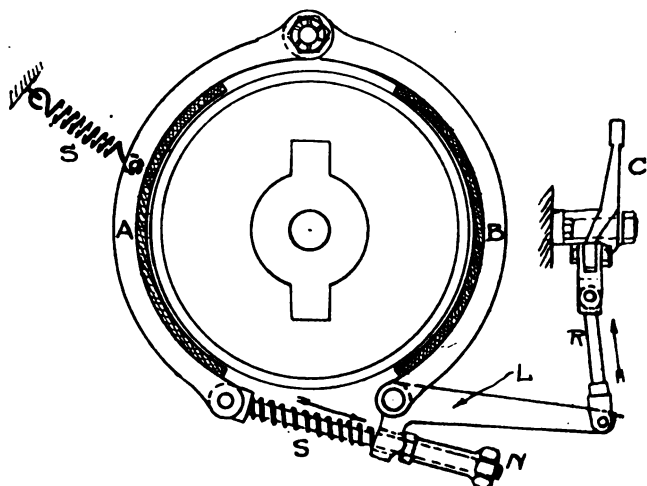


FIG. 96a.

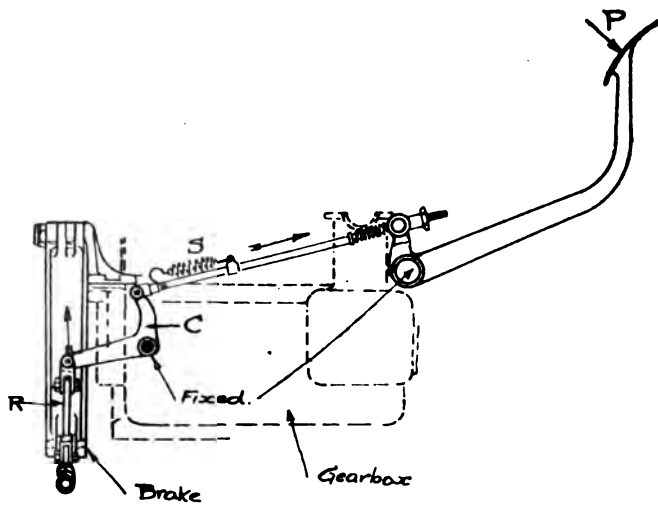


FIG. 96b.

turning the cam C and so separating the surfaces on which it works. In order to prevent the brakes remaining in action after the brake-lever has been released springs are attached to the two parts A and B, thus pulling them out of engagement. There are other methods of actuating both the external and internal brakes, but these all follow similar methods to the above. Figs. 96*a* and 96*b* show the method of action and the connection to the foot-lever of the transmission or foot-brake for a Wolseley car.

As the pedal P is pressed down the bell-crank C is pulled up through the rod below S (Fig. 96*b*) ; and this in turn acts on a second bell-crank lever (L) through rod R (Fig. 96*a*), thus pushing B and pulling A on to the drum against the springs S S S, which assure that A and B are pulled off the drums when the brake is not being used. A long adjustable nut (N) is shown, by means of which the tightness of the brake can be adjusted. In some cars this nut N is connected to a handle outside the frame, so that adjustments of the brake can be made without lifting the floorboards of the car or using a spanner.

Types of Brakes.—Figs. 97 and 98 show types of internal expanding brakes, Fig. 97 being the expanding part

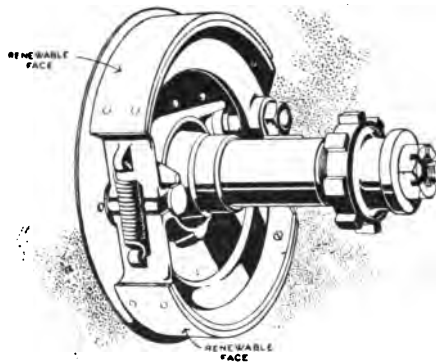


FIG. 97.

which goes inside the drum for an Austin car, and Fig. 98 showing the actuating lever, expanding brake, and drum for a Sunbeam car. Internal expanding brakes have the

advantage that they can be made dust-proof without any great trouble. All brakes should be designed so that the facings are easy to renew after wear. In travelling on severe hills the friction of the engine turning over rapidly can be used as a brake. If the car be put in first (or low) gear the engine has to turn over ten to fifteen times as fast as the road wheels : therefore the friction is considerable and is useful to ease the brakes on a long hill or if the hill be very steep.

As there is only one lever actuating the two brakes on the back wheels, some balance arrangement is desirable

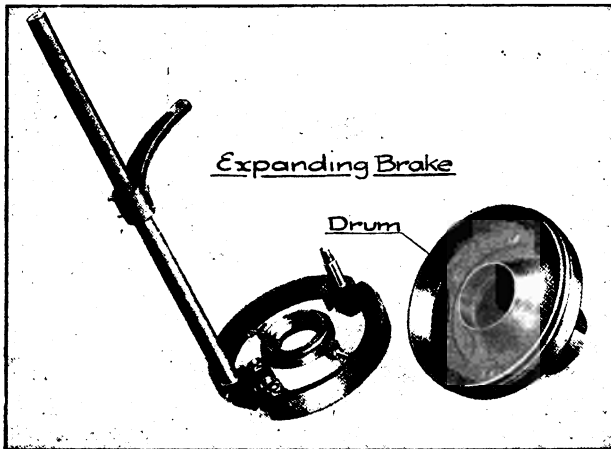


FIG. 98.—Expanding Brake.

in order to ensure that each wheel is carrying one-half of the braking friction. The method of doing this is shown in Fig. 99. As the brake lever is pulled on, the two rods to right and left brakes take up equal pulls—due to the pivot at P.

All brakes have an arrangement for adjusting the length of the rods between the lever actuated by the driver and the point of application of the brake, and great care should be taken to see that this adjustment is correct. When the lining of the brake wears and the various pins in the rods, as shown in Fig. 99, get slightly slack, there is a danger

that the full range of the foot-lever or of the hand lever may not suffice to give sufficient grip on the brake drum. Before this stage is reached an adjustment should be made in the length of the rod to take up this wear. This is

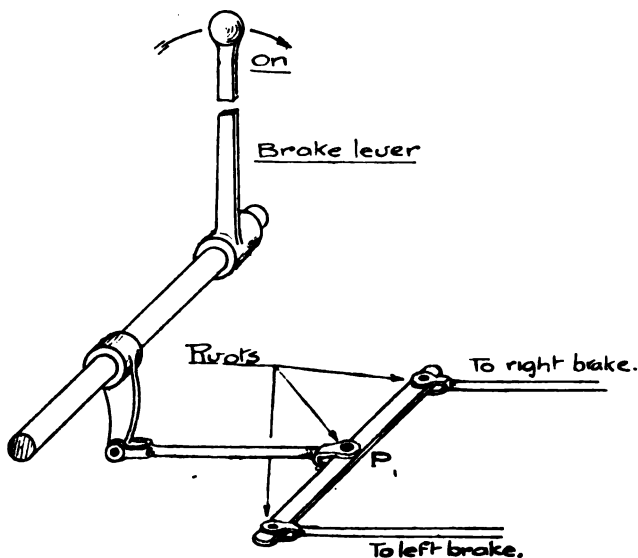


FIG. 99.—Compensation Device for Back Brakes.

usually done by screwing up a right- and left-hand shackle. Care should be taken to see that each rod is shortened by approximately the same amount, for the compensating adjustment shown in Fig. 99 is not always incorporated.

CHAPTER XII

STEERING AND CONTROLS

Lining of Wheels.—Before going on to study the steering mechanism and control, it will be well to point out the necessity for the plane of the wheels to be parallel to the direction of travel of the car. Suppose that, due to a knock, or due to wear or some other cause, wheel B (Fig. 100) takes a permanent set out of line as shown by the dotted line. If wheel B is now allowed to roll free from the car it will roll along BF; but due to the direction of travel of the car, it must proceed along BE. It can only do so by rolling

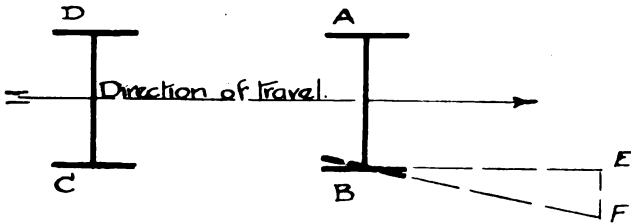


FIG. 100.

along BF and scraping or skidding sideways in a direction parallel to FE. It can be seen at once that the amount of rubber scraped off by this skidding action will be great, especially if the deviation of the wheel from the parallel is considerable. Assume a deviation of one inch in a diameter of 34 inches: this means that the wheel will have been dragged bodily in a sideways direction a distance of one mile in every 34 miles run by the car. When it is remembered that each wheel is carrying a load of, say, 500 lbs. to 1000 lbs., one easily can understand that a new tyre

may give out in a very short distance under such conditions of running.

Cornering.—When a car is going round a corner the wheels should, as far as possible, roll truly round; and there should not be any skidding—that is to say, all the wheels must be rolling round circles having the same centre; and as the back wheels cannot alter their angle relative to the car, that centre must be somewhere on the back axle produced, such as P (Fig. 101). Wheels C and D are at right angles to PC and PD: wheel B must be at right

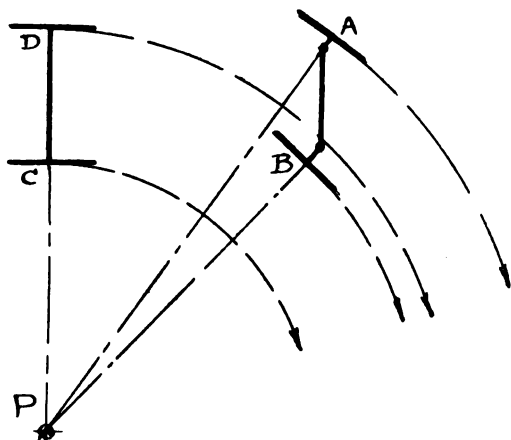


FIG. 101.

angles to PB, and wheel A at right angles to PA. This means that if true rolling is desired wheels A and B must be turned out of centre through different angles. The arrangement of rods, axle, and connections shown in Fig. 103 will give this true rolling round a corner approximately: proper design with regard to length of levers and the intersection of the continuation of standards B with the centre of the back axle will give an error of less than two degrees in every case.

Ackermann Steering Gear.—The front wheels run on what are called stub axles, which are connected to the front axle of the car by means of vertical pivots round which

they are free to turn. Fig. 102 shows the general arrangement of one end of the front axle of a Rover car, the wheel being turned about the vertical pivot by the arm S, which in turn is actuated by being connected up to the steering

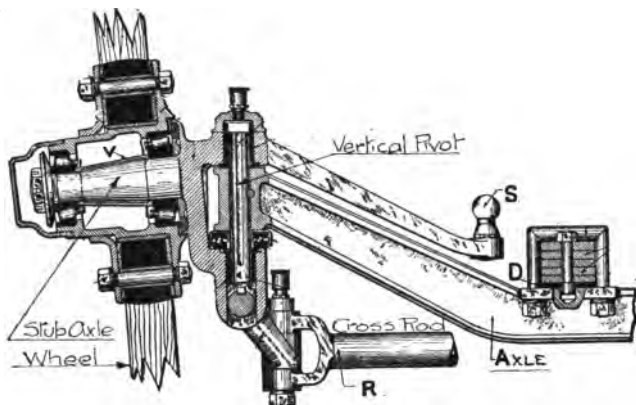


FIG. 102.—Stub Axle and Steering Rods.

wheel. The right-hand wheel is directly connected to the foot of the steering column by the rod shown in Fig. 104, and the left-hand wheel is turned by the cross rod to left wheel also shown in this figure. To turn the car to the left,

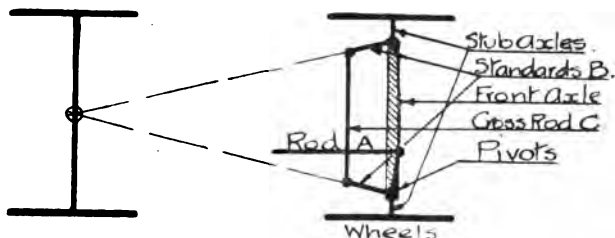


FIG. 103.

then, rod A (Fig. 104) is pulled back by the mechanism at the bottom of the steering column turning the piece to which standard B is bolted and so moving cross rod C to the right. The other end of the cross rod C is connected to a

standard similar to B, and so turns the left stub axle—to which the left wheel is attached—round its pivot. In order that the wheels may take up the proper angle as shown in Fig. 101, the lines joining the centre of the pivots to the ends of the cross rod C must meet each other at the centre of the back axle as shown in Fig. 103. This is not absolutely

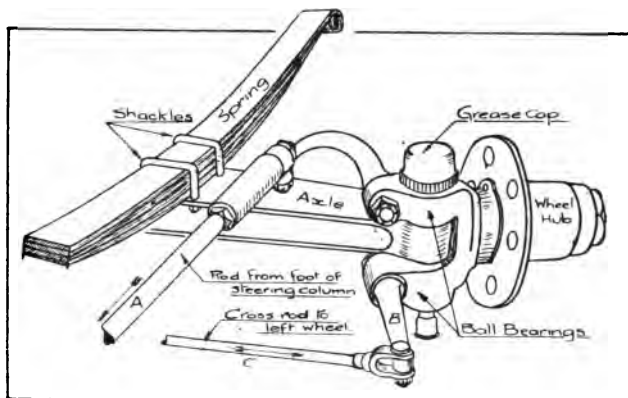


FIG. 104.—Stub Axle, showing connection to Steering Column and Cross Rod.

correct, but the error if properly designed is very small. This arrangement is known as the Ackermann steering-gear.

Steering Control.—As stated, the other end of rod A, Fig. 103, is attached to the foot of the steering arm by means of a spring ball-joint as shown in Fig. 105; the other end of the shaft, supporting the upper end of the steering arm, has a worm wheel—in some cases only a part or sector of a worm wheel—keyed to it. This worm wheel gears with a worm on the foot of the steering column. In this way any movement of the large wheel at the top of the steering column (Fig. 105) makes the worm sector rotate about its axis, carrying with it the steering arm, the lower end of which transmits its movement through rods to the stub axles. Fig. 106 also shows details of this.

Throttle and Spark Control.—The steering column is usually hollow, and down its centre are concentric rods for

controlling the ignition and the throttle (that is, the amount of gas supplied from the carburettor to the engine). The levers for actuating these controls are shown in Figs. 105 and 107, and their connections to the magneto and carburettor—through the bottom of the steering column—in Fig. 105.

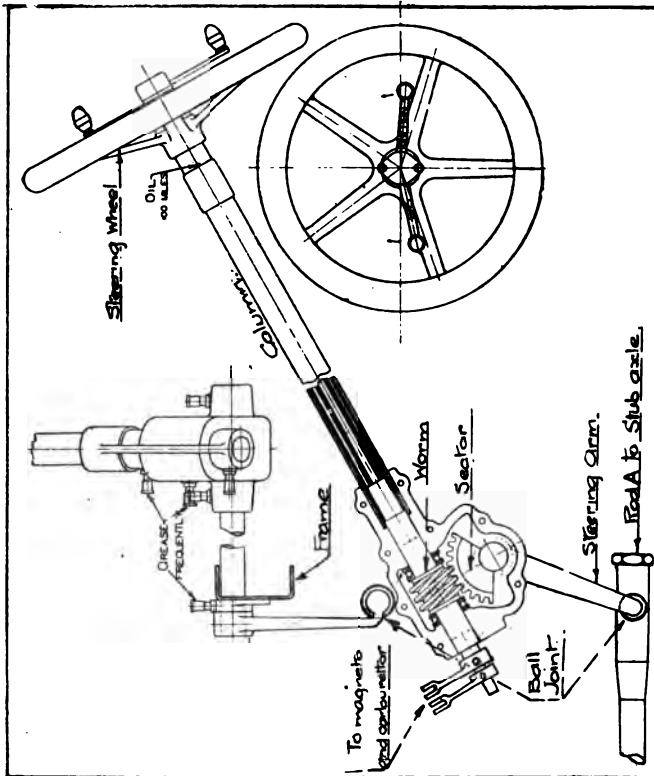


FIG. 105.

The gas or carburettor control is usually inter-connected with a lever at the driver's foot, called an accelerator pedal; thus the speed and power developed by the engine can be controlled by hand or foot.

Other Controls.—Fig. 108 shows this foot throttle

THE MOTOR CAR

and also the arrangement of steering wheel, clutch, and foot brake pedals. On the dashboard in front of the driver there is also a switch by means of which the magneto can be cut out and so stop the engine quickly ; also a pressure gauge, showing the pressure in the petrol tank (if carburettor is

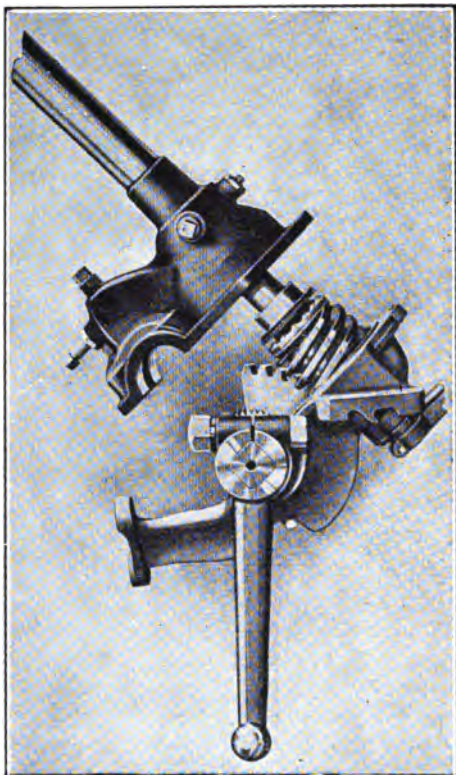


FIG. 106.—Steering Gear.

pressure fed) ; an indicator showing whether the oil is circulating in the engine or not ; and a switch for the battery ignition if dual ignition is fitted. As stated earlier the gear lever and hand-brake lever are usually at the driver's right hand, though in some American cars these are placed in the centre of the car at the driver's left hand.

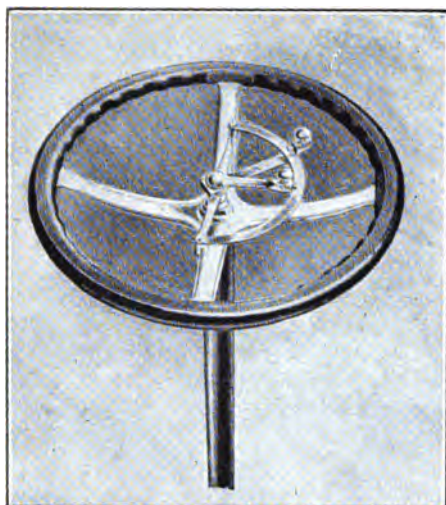


FIG. 107.—Steering Wheel with Throttle and Spark Levers.

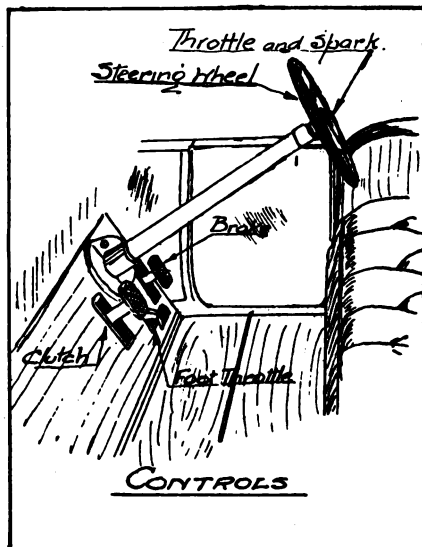


FIG. 108.—Controls.

Lining up.—Before leaving the questions of steering and the true rolling of tyres, a method of testing front wheels

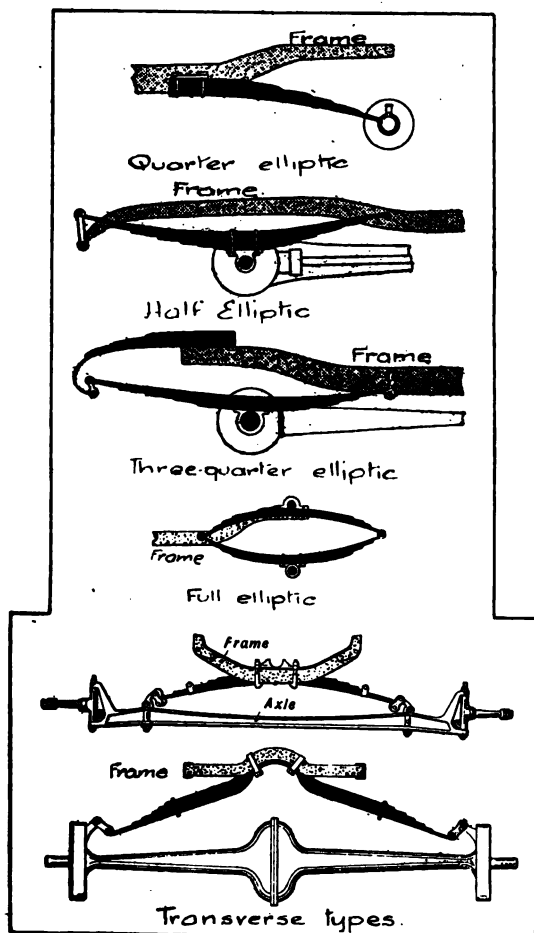


FIG. 109.—Types of Springs.

for true alignment is given. Take a string and stretch it along the right side of the car, against the wheels about

nine inches above the ground ; by means of the steering wheel adjust the right front wheel so that it is in line with the string. Take the string to the other side of the car, and again test. If the left front wheel is not parallel to the string, the car should be sent to the garage for adjustment. Another cause of extreme wear on the front tyres is play in the steering wheel, due to a worn quadrant at the foot of the steering column or to pins worn slack in the joints of the rods. Due to a collision or to a skid in which the back wheels have struck some object sideways, such as the kerb, these may be out of truth, and if so they should be looked to at once, as when wheels are out of line not only do tyres wear more rapidly but the car becomes difficult to control.

Springs.—The whole weight of a car may be divided into two divisions—the unsprung parts, which consist of

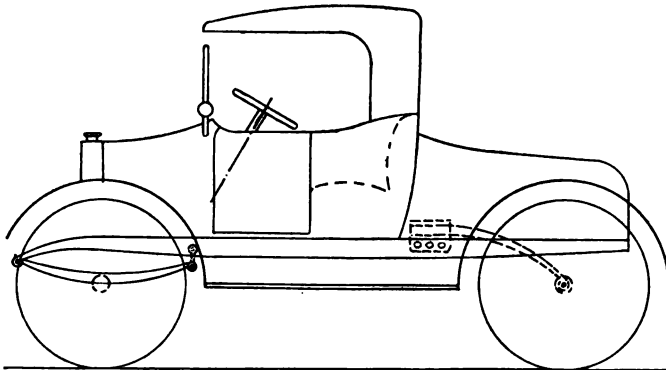


FIG. 110.—Application of Springs, showing Semi and Quarter Elliptic Types.

the four wheels, the axles, differential, and in a few cases the gear box ; and the sprung parts, embracing body, engine, clutch, gear box, and frame—the connection between the two being by means of the springs. As the wheels of a car travel along the road they meet little inequalities, such as projecting stones and holes in its surface. These cause the wheels, axles, etc., to vibrate violently ; so that to give easy and comfortable riding to the passengers, and also

to save the rest of the car and mechanism from shocks which would soon shake it to pieces, cushions or springs have to be provided. These usually are modified forms of the types used in horsed vehicles. Various types of springs used in motor cars are shown in Fig. 109, and Fig. 110 shows the application of semi-elliptic front springs and quarter elliptic rear springs to a design for a cycle car. As all the weight of the car, and all the shocks due to road inequalities, which may be very great, are taken up by the springs, these must be very strong.

Shock Absorbers.—When exceedingly strong springs are used, however, the riding becomes much less comfortable,

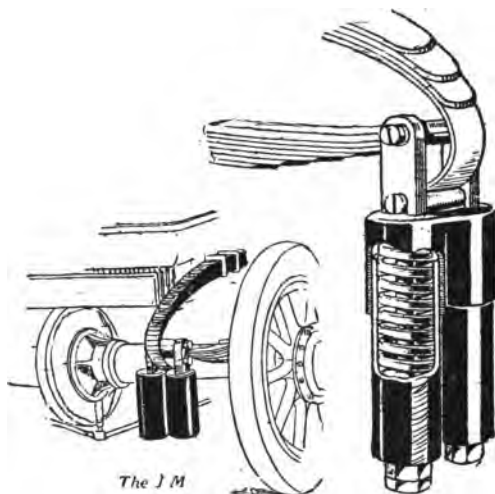


FIG. 111.—Shock Absorbers.

due to the “bounce,” or want of flexibility, of a strong spring ; and in order to get rid of this bounce, especially at the rear of the car, auxiliary springs, either in the shape of short steel spiral springs or pneumatic cylinders, are often fitted between the rear end of the spring and its shackle attachment on the body as shown in Fig. 111. In order that springs may give the best service they should be

cleaned and oiled fairly often. Special tools can be obtained which prise the blades apart while grease is being inserted.

Frames.—Supported on the springs, and coming between them and the body proper, is the frame of the car. This consists of pressed steel sections, generally pressed to the channel shape shown in Figs. 105 and 112, this shape giving the greatest strength for the least weight. To the frame are bolted the engine, gear box, steering column, and all shafts and pivots for gear levers, brakes, etc. Generally the frame consists of two extra strong long main girders

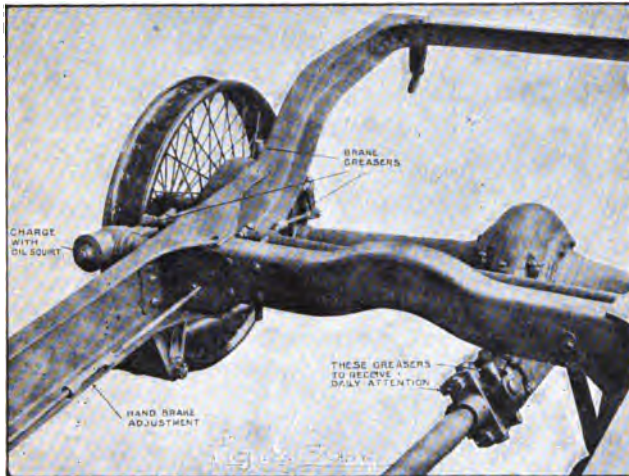


FIG. 112.—Frame.

running the whole length of the car, with suitable cross girders to bind them together, forming a very strong rectangular structure.

Fig. 112 shows clearly the method adopted for fixing the cross girders to the main girders. As well as this main frame a subsidiary frame of lesser width is sometimes provided, extending from the radiator to halfway along the car, and to this sub-frame the engine, clutch, and gear box are bolted. To give a large turning angle to the wheels, in order that the car may turn in a small circle, the width

of the frame at the front of the car is made less. This is technically called giving the front wheels a large steering lock. Also, to give as much clearance as possible to the back axle and back portions of the car, the frame is usually upswept as shown. Fig. 113 shows a typical motor car frame, as also the frontispiece.

CHAPTER XIII

CARE OF THE CAR AND TYRES

Periodical Attention.—When a car is bought the purchaser usually receives a handbook on the car, explaining the action of the various parts and giving hints as to lubrication, greasing, etc. A number of diagrams and drawings usually are included, the most important of which is probably the oiling and greasing diagram. Fig. 113 shows this diagram, the car illustrated being a 20 h.p. six-cylinder Standard. The various points at which grease and oil have to be applied are marked, and in some cases the mileage is stated, after which the oil or grease requires to be renewed. The figures given must be taken as a maximum, and the careful owner generally looks to the lubrication of these parts at more frequent intervals than those mentioned. As a very considerable amount of damage and excessive wear of the various running parts may be caused by neglecting the lubrication, the beginner should get the agent to go over with him all the places requiring attention, and a list of all the points at which lubricant should be applied and the intervals at which this should be done should be drawn up and rigidly adhered to. Certain points should be lubricated daily; for others weekly or even monthly attention is all that is necessary. On the same list the other matters which require periodical attention should be noted.

Fig. 114 shows details of lubricators and grease-boxes, a turn of the lid in the latter forcing a quantity of grease into the bearing. The following is a list which can be modified to suit the car involved.

Daily Attention.—Wash and clean the car. Look to petrol tank and radiator, fill if necessary, and see that oil

in engine sump is up to the proper level. Tyres should be inspected, and inflated to the correct pressure if necessary. Lubricate all the steering pins and connections by putting

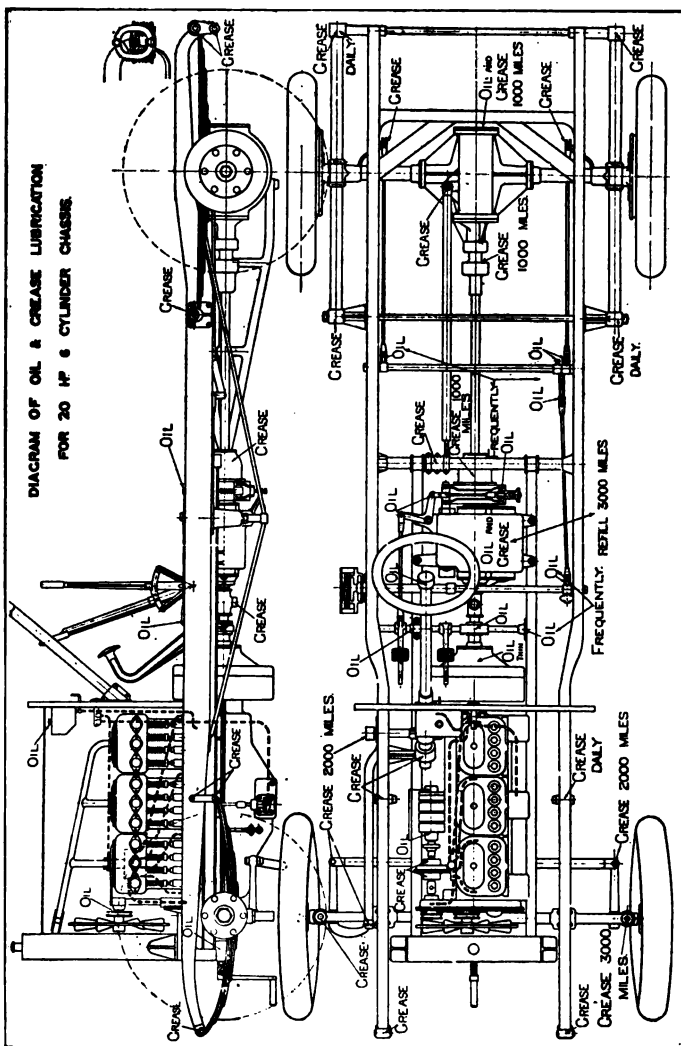


FIG. 113.—Lubrication Diagram.

a few drops of oil in the small lubricators or oil-holes ; or give the caps of the grease cups one or two turns where this type of lubrication is employed. The clutch bearing should be lubricated, and all the pins, etc., on the springs should be attended to. Many motorists of considerable experience may think daily attention to the above points too much trouble and unnecessary ; but it should be remembered that these are the vital points in the running of a car, and daily lubrication and attention mean daily inspection. A broken spring blade or defective steering gear may thus be found, and so serious delay or even accident on the road may be saved. Soft water should be put in the radiator where

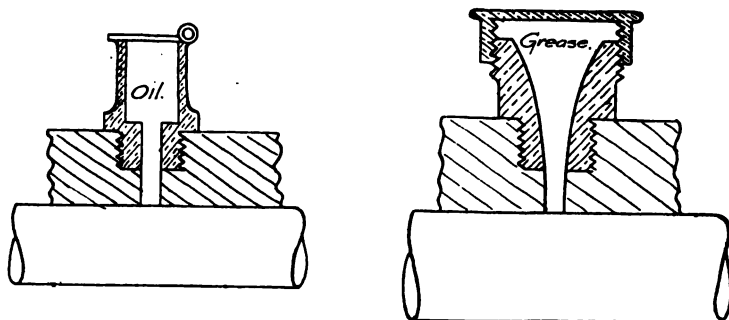


FIG. 114.—Oil and Grease Lubricators.

possible, to prevent deposit, and only clean water should be used. All the above duties (but especially those pertaining to lubrication) should be performed according to some plan, each joint being taken always in the same order. This saves time and assures that none are overlooked.

Fortnightly.—At longer periods, depending on the mileage run (say every 400 miles), but at times not farther apart than a fortnight, the following should be attended to, the daily attention being given at the same time. All the lubricators should be attended to, and every oil-hole, no matter how awkward to get at, should receive its quota of oil. Method in this case is of the utmost importance, and a full list of all the points of application will enable the beginner to assure himself that every point has been attended to. It should be arranged to start at some point

on the car ; and in the course of the work to travel right round it, returning to the starting-point. At this period greasers should all be refilled with grease. This is also a convenient time at which to draw off a little of the petrol from the bottom of the tank, thus getting rid of any water or sediment that may have entered.

About Three Months.—About every 2000 miles it is advisable to give the following extra attention. If dual ignition is fitted, have the accumulators recharged (this should be done every six weeks, whether the accumulators are run down or not). After a time, due to heat, impurities, and friction, the lubricating oil becomes somewhat spent and tends to deposit a thick sediment at the bottom of the sump. For this reason the crank case should be cleaned out periodically. In order to make it thoroughly clean a quantity of paraffin should be put in and the engine turned round rapidly by hand, after which the engine can be filled with clean lubricating oil. Clean the oil and the petrol filters. Clean out the gear box and put in fresh grease. Fill universal joints with fresh grease. Clean out the back axle and refill with the lubricant recommended. Drain out the radiator and refill with a solution of washing soda, and run the car for a day ; then wash out the soda, and fill up again with clean soft water. Lubricate the leaves of the springs by removing the clips and jacking up the car to take its weight off the springs ; separate the blades slightly (there is a tool specially supplied for this), and smear thick oil or thin grease between them with a flat knife. Test and adjust all brakes. (This is most important.) Clean and grease detachable wheels. (Instructions *re* tyres will be given later.) Every nut on the car should be examined, and if necessary adjusted ; also all small screws, fastenings, etc., in the electric circuit and elsewhere should be tightened up.

About 5000 Miles.—Remove the cylinders and clean off the carbon deposit on the heads of the cylinders and pistons. This may require to be done oftener than at 5000-miles periods, in fact, whenever the engine begins to knock badly the cylinders should be cleaned. It is also advisable to clean out the carbon from behind the piston rings. Dismantle and examine the steering gear, and

re-adjust if necessary. The exhaust box or silencer should be cleared of soot and carbon periodically. At all times an intelligent interest must be taken in the car. A few minutes spent in looking over and adjusting it at odd times may save a great deal of road trouble and a large repair bill. A car of good make, if well looked after, should run 15,000 to 20,000 miles before requiring to be overhauled.

Washing the Car.—The car should be washed frequently, especially when new; and this should be done before the mud dries hard. Cold water only should be used, and should be sprayed on from a hose. The mud should not be wiped off with a cloth or sponge. When clean, the body should be wiped with a clean wet sponge, and then dried with a chamois leather. Never leave a car in the rays of the sun, as this may cause blisters, and will destroy the lustre of the paint and varnish.

Silencers.—When the exhaust valve opens, the gases inside the cylinder are still white hot—that is, somewhere in the region of 1000 to 1500 degrees F.—and the pressure may vary from 30 to 50 lbs. per square inch. It has been found that it is much better to open the exhaust valve early—that is, before the end of the power stroke—and give a lead to the exhaust gases than to continue to expand the gas to the end of the stroke. The reason for this is to get rid of the spent or burnt-out gas as thoroughly as possible and so permit the engine to run at a high speed. If this pressure of about 40 lbs. were allowed to discharge straight into the air it would cause a nuisance and a danger, due to the noise and the heat. There are several methods of getting rid of these, one being to discharge the exhaust gas through a long pipe into a large box at the rear of the car, where it expands down to atmospheric pressure—due to the cooling effect and the large space. A second method is to make the gas pass through small holes and take a tortuous course in the box.

The first method, if the box is properly designed, has the advantage of putting very little back pressure on the engine, and thus the loss of power is very small; but it has the disadvantage of requiring a large and heavy box, or of having more than one. In the second method the

size of the box required is comparatively small ; but, due to the small area and tortuous course of the passages, considerable back pressure may be set up and some power lost

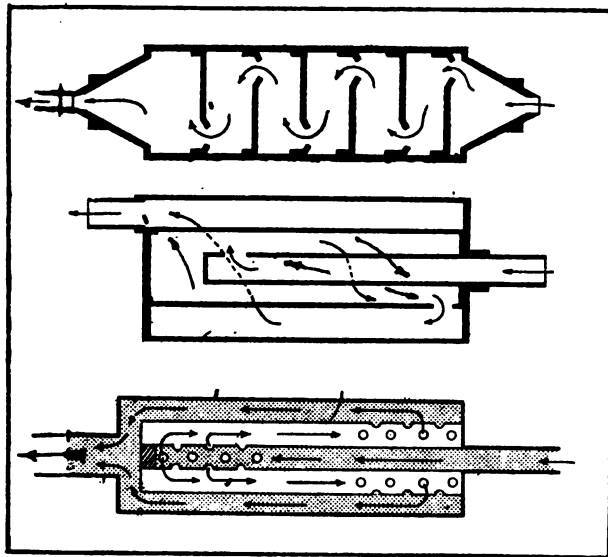


FIG. 115.—Types of Silencers.

in overcoming this. A middle course is generally followed by the modern designer. Fig. 115 shows types of silencers.

Tyres.—It is only necessary to give a few hints with regard to tyres, because most of the tyre firms publish pamphlets giving instructions on the care and upkeep of these, and a request to any of these firms will bring the booklets per return of post. The following notes are taken from a booklet issued by the Michelin Tyre Co. Taking pressure first, it may be said that correct pressures in the tyres will increase their life enormously, and all the tyre firms complain bitterly of under-inflation. Even the most expert motorist cannot judge as to the pressure in a tyre by merely looking at it and feeling it, and it is necessary to use a pressure gauge, which gives the pressure in a tyre by merely applying it to the valve after the cap has been taken

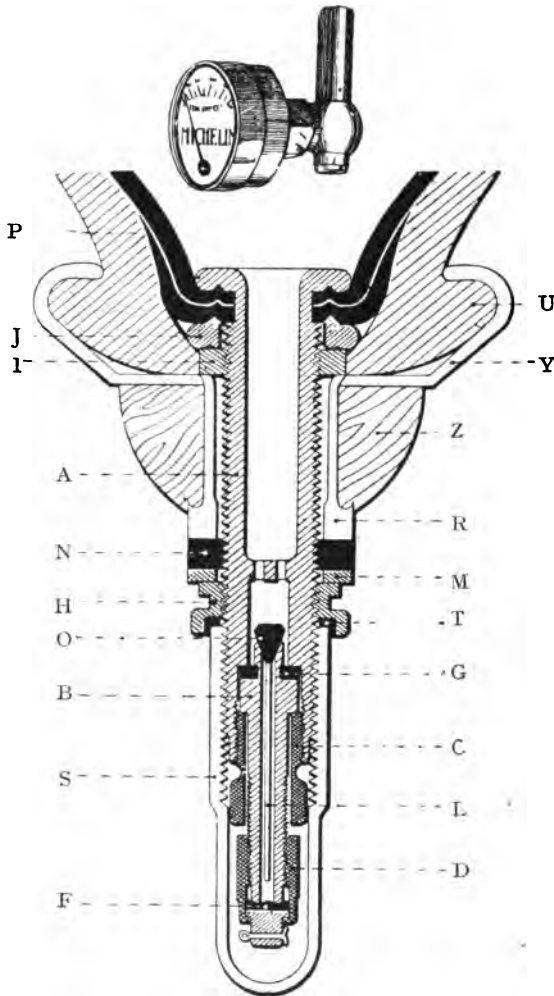


FIG. 116.—Tyre Valve.

- A. Valve Body. B—Centre Piece. C—Nut. D—Valve-cap. F—Rubber Disc. G—Rubber Washer. H—Large Nut. I—Hexagonal Nut. J—Metal Washer. L—Valve Plug Pin. M—Metal Washer. N—Rubber Washer. O—Valve Plug. P—Rubber Valve Tab. R—Hollow Rivet. S—Valve-hood. T—Leather Ring. U—Bead of Cover. Y—Steel Rim. Z—Wood Felloe.

off, pressing up needle L (Fig. 116), and so allowing the air pressure to reach the gauge. The following table gives approximate values for pressures, etc. :—

PRESSURES.

Size of Tyre.	Maximum Weight on Tyre.	Maximum H.P. of Engine.	Pressure in lbs. per square inch required depending on Weight on Wheel.
65	520 lbs.	8	46 to 60
75	600 lbs.	10	42 to 60
85	660 lbs.	12	42 to 60
90	880 lbs.	14	42 to 65
105	990 lbs.	18	42 to 70
120	1320 lbs.	above 18	42 to 70
135	1430 lbs.	above 18	42 to 70

The above figures are for back tyres. Front tyres should have a pressure about 7 lbs. per square inch less than above figures.

Care of Tyres.—Do not allow the rims to rust, or they will become jagged and cut the covers at the bead. When rough, the tyre should be taken off and the rim filed smooth, finishing with emery paper ; and a coat of varnish should then be given. Bent parts in the rim, due to collisions with stones or other articles, should be straightened as soon as possible, and any projecting rivets or screws in the rim should be filed down flat. Small surface-cuts on covers should be filled with mastic to keep out grit and water, these having a tendency to rot rubber and canvas and so cause bursts. Any oil falling on the tyre should be wiped off at once with a petrol-moistened rag. Oil rots the rubber and causes it to lose its grip on the canvas underneath. Never run with under-inflated tyres. See that wheels are parallel, especially front wheels ; and loose or bent wheels should be looked to.

“Don’ts.”—Don’t start or stop abruptly. Don’t stop too quickly. Don’t take quick turns at corners. Try to prevent skidding. Travel slowly over newly-metalled roads. Don’t use too much chalk for the inner tube, and don’t

put a wet tube into the cover—dry it first. Spare covers should be in a case. Six months' hanging exposed, even if unused, means that half the life of the tyre is already gone. Don't travel at high speeds over rough roads. Remember that if you double the average speed of a car the running costs will go up from 3 to 4 times.

CHAPTER XIV

THE TWO-STROKE ENGINE

Three Idle Strokes.—From the earliest days of the internal combustion engine engineers have deplored the three idle strokes out of four in the ordinary or four-stroke cycle engine—that is, idle so far as positive work is concerned—and many attempts have been made to reduce the number of non-working strokes. These have been successful in the case of large stationary engines, and even in engines for motor vehicles a considerable amount of success has been obtained with an engine whose cycle occupies only two strokes or one revolution. To make matters quite clear, it may be mentioned again that there are four separate actions which go to make the series or cycle of actions necessary in the ordinary internal combustion engine. These are : (1) the supply of the fuel and the air necessary for its combustion ; (2) the compression of the charge of fuel and air—this is necessary, because unless the charge is compressed before firing the efficiency of the engine and the power developed are low ; (3) the explosion and expansion of the hot gas, thus driving out the piston and doing work ; and (4) the getting rid of or exhausting the burnt-out charge. Shortly these are named : (1) suction ; (2) compression ; (3) explosion and expansion, or working ; and (4) exhaust. In a four-stroke cycle engine each of these occupies approximately one stroke—the strokes being called suction stroke, compression stroke, working stroke, and exhaust stroke. It is only on the working stroke that energy is being transferred from the hot gases on the one side of the piston to the crankshaft at the other end of the connecting rod. On the other three strokes not only has the crankshaft, with its storage reservoir in the shape of the flywheel, to give out enough energy

to do the continuous work performed by the engine in driving the car or cycle, but it has also to supply the energy to suck, compress, and exhaust the gas.

The Two Strokes.—It is evident that if the four necessary operations are to be performed in two strokes each action cannot occupy one whole stroke. Taking these in turn : The suction is performed on the crankshaft or under side of the piston during its upward stroke, the

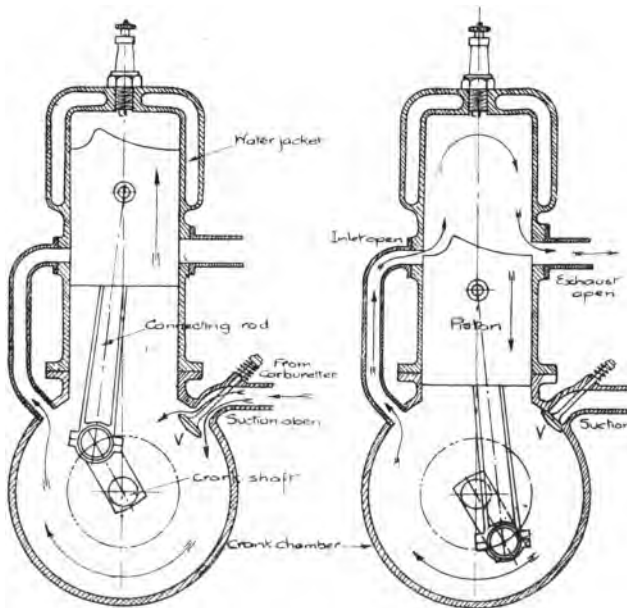


FIG. 117.

charge being drawn into the crank chamber (which must, of course, be pressure-tight) through a spring-controlled valve in its side. Compression takes place partly on the under side of the piston as it travels downwards, and partly on the upper side on its upwards stroke in the ordinary way. The working period occupies nearly a whole stroke. The exhaust, however, only occupies part of a stroke.

Fig. 117 shows diagrammatically the arrangement of

the various parts of the engine and their relative positions just before the end of the compression stroke ; and as the piston travels upwards, creating a partial vacuum in the airtight chamber, a charge of gas and air is sucked in from the carburettor through the spring-controlled valve V. Fig. 117 also shows the piston near the end of its working stroke. As its downwards sweep reduces the space in the crank chamber the pressure there increases. Valve V closes, and by the time the piston has reached the bottom of its stroke the charge of gas and air is under a considerable pressure. Before reaching the end of the stroke the piston uncovers a rectangular opening in the side of the cylinder (shown open on the right in Fig. 117), and the burnt-out gases, still under considerable pressure, rush out into the exhaust pipe and so to the silencer. When the piston reaches the end of its stroke it has uncovered another opening (shown on the left-hand side of the cylinder) which is connected, by means of a passage, to the crank chamber, from which the compressed inlet charge rushes into the space above the piston. The tendency of the new charge is to rush straight across to exhaust, so a deflector ledge is cast on the top of the piston, which to a great extent prevents this and tends to give the new charge the path shown by the arrows. As the piston again moves up both ports close and the charge gets its final compression on the top side of the piston, whilst a new charge is drawn into the crank case as before.

Timing.—Fig. 118 shows the various crank positions at which these actions take place, both for the four-stroke and the two-stroke cycle, and as the crank is rotating uniformly the circles marked "exhaust," "inlet," etc., on the diagrams represent the relative times which are allowed for these actions, assuming that the engines are rotating at the same speed. It will be seen that whilst the times allowed for inlet and exhaust in the two-stroke cycle are less than the times given in the four-stroke cycle there is still a considerable length of time available for these without reducing the length of the working stroke to any great extent, and Fig. 119 shows theoretical cards from these engines. It should be remembered that the area of these cards represents the work done during one working

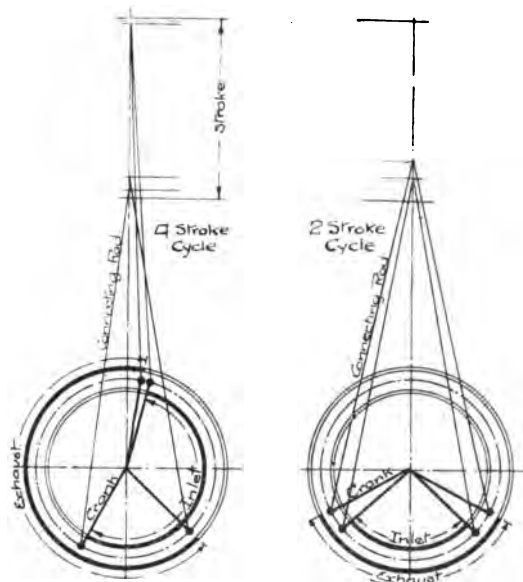


FIG. 118.

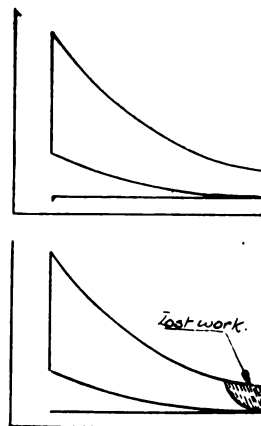


FIG. 119.

stroke in each engine respectively, and it can be seen that the two-stroke engine card is *theoretically* very little smaller than the four-stroke engine card, so that under ideal conditions a two-stroke engine should develop almost twice the power of the four-stroke engine of the same size.

Advantages and Disadvantages.—It will be necessary at this stage to discuss the advantages and disadvantages of the two-stroke type, and see how the disadvantages can be minimised. Taking the advantages first: More power is developed for the same weight of engine, though this is much less than twice that developed in the four-stroke

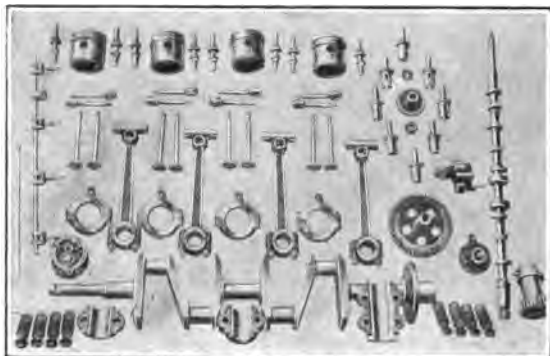


FIG. 120a.—Parts in the ordinary 4-cylinder 4-stroke cycle Engine.

engine of the same dimensions. There are no valves to look after or to grind in. Construction is simple. And as there are few moving parts (see Figs. 120a and 120b) the chances of a breakage are much less. To put against these advantages there are several disadvantages. Perhaps the most important is the loss of fresh gas, a certain amount of this going straight to exhaust in spite of the deflector on the top of the piston. Further the exhaust or burnt-out gases are not positively cleared out, and a considerable amount remains in the cylinder, taking up space that ought to be occupied by a fresh charge, and so a loss of power is experienced. As the crank chamber is under pressure the

bearings, joints, etc., have to be pressure-tight joints or compression is lost, together with some of the fuel ; and as there is a considerable amount of oil being churned up in the crank-chamber, for lubricating purposes, some of it is carried up with the charge into the cylinder, where it fouls the plugs and valves and deposits carbon in the



FIG. 120b.—Parts in the 2-cylinder 2-stroke " Valveless " Engine.

cylinder. This increases the amount of lubricating oil required very greatly, and thus causes heavier running costs.

Disadvantages overcome.—Many attempts have been made to get rid of these defects, and probably the most successful of these is the engine used in the Valveless car. In this engine the cylinders are two in number, cast together, with a common combustion chamber at the top as shown in Fig. 121. It should be noted that the inlet ports are in one cylinder and the exhaust ports in the other, so that when the new charge enters the cylinders through the inlet port E it has to travel up to the top of the common combustion chamber and over the dividing wall between the cylinders before there is any danger of its passing out of the exhaust port unburnt. This does away with the excessive consumption of fuel common to most engines working on the two-stroke cycle. Again, due to this the

new charge has the effect of sweeping out the burnt-out gas and so doing away with another of the defects common to the two-stroke cycle type of engine. Another improvement in this engine is the method of lubrication. Positive lubrication from an oil pump is supplied through pipes direct to the surfaces concerned, and so the splash system which churns up the oil in the crank chamber is done away with,

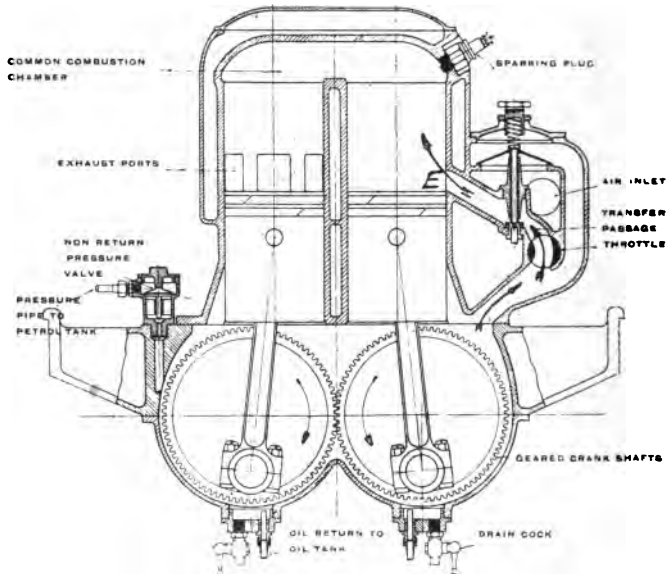


FIG. 121.—Showing the two cylinders with the common combustion chamber, the carburettor and transfer passage from base chamber to cylinders, the two crank shafts, geared together, and which revolve in opposite directions, the exhaust port, the sparking plug, and the oil return from base chamber back to the oil tank.

thus ensuring that the air compressed in the crank chamber is fairly pure and preventing the excessive consumption of oil and the sooting up of the plugs and cylinder heads. Any surplus oil falling into the crank chamber is immediately pumped, by the action of the gear wheels which connect the

two crankshafts together, back to the oil tank. The petrol does not enter the crank case, but the partially compressed

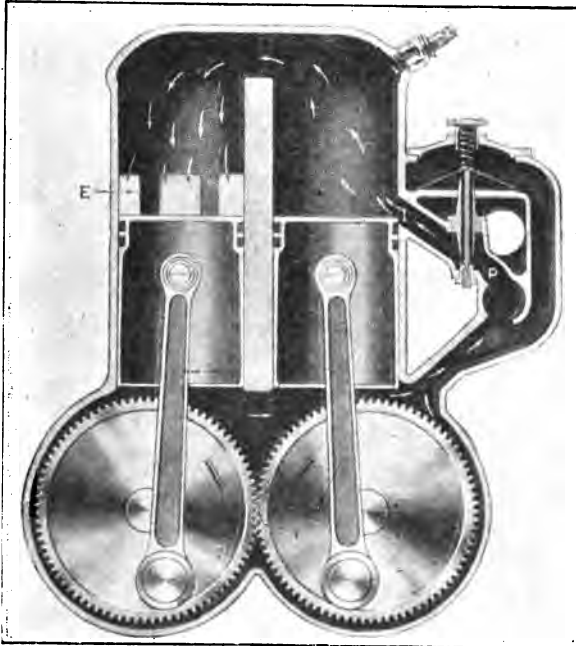


FIG. 122.—Showing inlet port uncovered. (Compressed air rushes into cylinders, displacing exhaust gas.)

air picks up its quota of fuel as it passes over the jet of the carburettor at A (see Figs. 122 and 123).

The Carburettor.—Fig. 123 shows the form of the carburettor, the action of which is as follows: The main body of the carburettor is cast integral with the cylinders, and the float chamber and pipe connection to the jet are attached to this. When the pistons ascend, the vacuum caused in the crank case and carburettor passage lifts the air valve or disc and the needle off their seats. The petrol is sucked into the passage at A and the air past the air disc at B, the amounts varying with the speed of the engine.

When the pistons reach the top of their stroke the suction action—and therefore the vacuum—ceases to exist, and this with the aid of spring B closes the air disc and the needle, preventing any further ingress of air and petrol. The pistons are now travelling downwards, and so the air

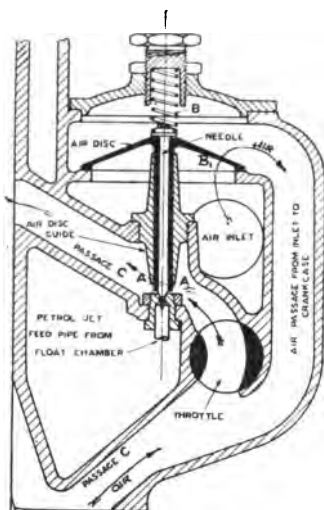


FIG. 123.—Showing throttle, carburettor jet, air disc, etc.

sucked into the crank case is partly compressed; and when they come to the bottom of the stroke this compressed air rushes through the throttle passage to the cylinder, picking up the petrol lying at A in its course, thus forming an explosive charge in the cylinders. The pistons on their next up-stroke complete the compression, and the ignition of the charge and the working stroke follow in the usual manner. Without a doubt this particular engine, so far as economy and smooth working are concerned, is a great advance on the ordinary type of two-stroke engine, and it should take a prominent place in the immediate future amongst the special

engines used for driving cars, its few parts and simple action making for reliability and small repair bills.

Details of Engine.—As will be seen from the diagrams, the inverted U-shape of the cylinders necessitates the employment of two crank shafts, these being connected by means of gear wheels, only one shaft being used as the driving shaft of the car. Two flywheels are used, one on each shaft. Whilst the two explosions occurring in the cylinders at the same time tend to make the torque or driving curve rather uneven, the two flywheels help to minimise this.

There is the further advantage that, due to the simultaneous actions of the two lines of working parts in opposite

directions, the inertia and side-pressure forces (see Fig. 124) are in perfect balance. This is a valuable advantage in an engine running at the high speeds common to motor engines, for at these speeds the unbalanced inertia forces may become very great and cause considerable vibration. The two flywheels, running in opposite directions, also

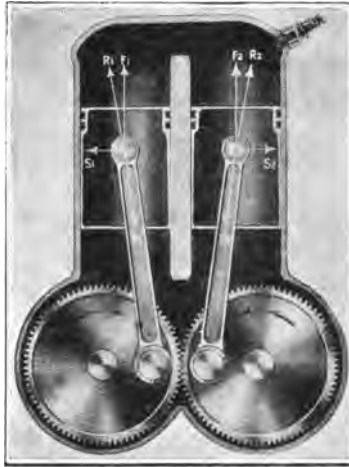


FIG. 124.

neutralise the forces due to gyroscopic effect when turning corners and make the car less liable to sideslip on greasy roads. There are a number of other makers who specialise in cars driven by two-stroke engines, each of whom have some special method of overcoming the disadvantages inherent to the two-stroke cycle.

CHAPTER XV

SLEEVE AND ROTARY VALVE ENGINES

Early Design.—In the earlier days of motor-car design before the science of engine-building had received so much attention where details are concerned, one of the drawbacks of the ordinary mushroom or tappet valve engine was the noise made by the action of the valves hitting their seats; the tapping of the valve stems on the tappets, and the want of silence generally due to little metal-to-metal noises in the valve gear and cams.

Knight Sleeve Valve.—In order to overcome this, and to gain other advantages, Charles Knight invented

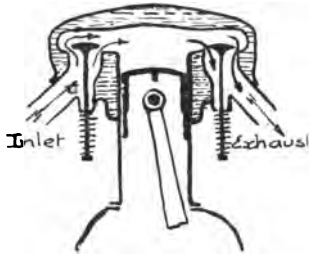


FIG. 125a.

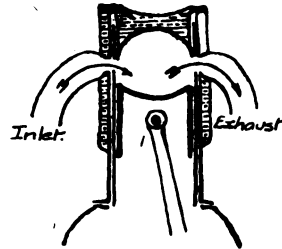


FIG. 125b.

the "silent sleeve valve" engine called after him. In this engine the cycle of operations followed in the cylinder is exactly the same as in the mushroom valve engine—namely, the Otto cycle, which consists of (1) suction stroke; (2) compression stroke; (3) explosion or working stroke; and (4) exhaust stroke, the main difference from the ordinary or tappet valve engine being in the method of admitting the gases and their discharge from the cylinder. In the

tappet valve engine the gases have rather a tortuous passage from the carburettor through the induction pipe past the valve, after which their direction has to be changed to one at right angles to the natural path of their flow, and

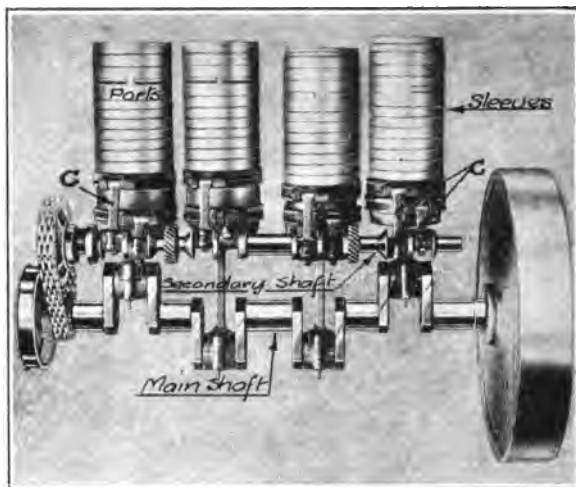


FIG. 126.—Showing Sleeves and Secondary Crank Shaft.

so into the space behind the piston as shown in Fig. 125*a* ; whereas in the slide valve engine the gases flow straight into the cylinder through a rectangular port in its side.

The Sleeves and Ports.—These rectangular ports are opened and closed by means of sliding sleeves between the piston and the walls of the cylinder, these sleeves being operated by means of short connecting rods which connect them to a secondary crank shaft geared to the main shaft of the engine and working at one-half its speed. Fig. 126 shows the main crank shaft and the secondary crank shaft driven from it by means of a chain ; it also shows the eight sleeves (two for each cylinder) driven by the short connecting rods C.C., Fig. 127 is a section through the engine, showing piston and connecting rod, sleeves, crank shafts, oil trough, pumps, etc. The following table gives the names of the various parts :—

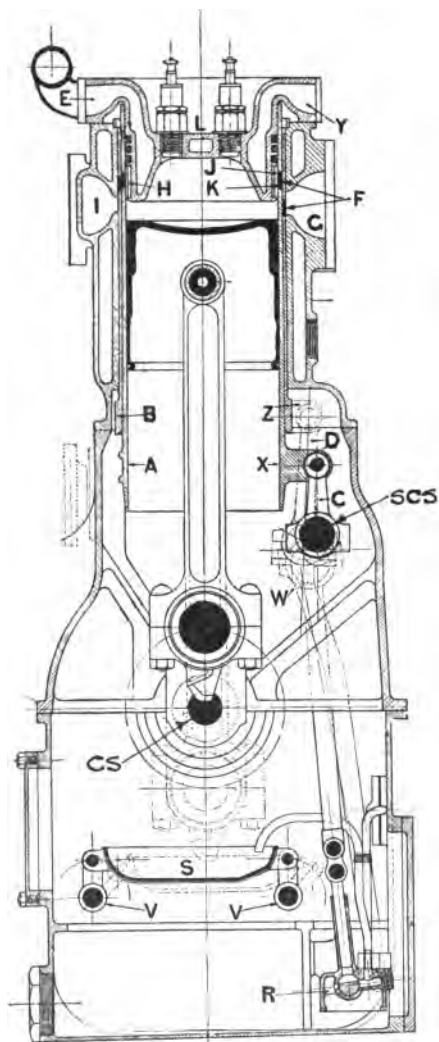


FIG. 127.—Knight Sleeve Valve Engine.

WORKING PARTS.

- AB, Sliding sleeves.
- CD, Small connecting rods.
- CS, Crank shaft of engine.
- SCS, Secondary crank shaft.
- IG, Inlet and exhaust ports in cylinder walls.
- H, Inlet ports in sleeves.
- F, Exhaust ports in sleeves.
- XZ, Projecting lugs on sleeves for driving them.
- E, Cooling-water inlet.
- Y, Cooling-water outlet.
- L, Sparking plugs.
- S, Oil trough for big ends.
- R, Oil pump.

It should be noted that there are two sleeves, it being necessary in this type of sleeve valve engine to have this number in order that the ports in the sleeves should come into register with the openings in the cylinder walls at the proper time. The travel of the sleeves is comparatively small, and thus their maximum velocity is only about one-eighth to one-tenth that of the piston. The ports are of large area, thus allowing easy entry and exit of the gases.

The Action of the Sleeves.—The action is as follows :

As the piston reaches the top of the exhaust stroke the left-hand openings (H) of the two sleeves come opposite each other and opposite the port (I) in the cylinder wall (see Fig. 128) ; the piston travels down ; and a charge of gas and air is sucked in from the carburettor in the usual way. Just after the piston reaches the bottom of the stroke the ports in the sleeves travel up into the space between the cover and the cylinder (see Fig. 129), and

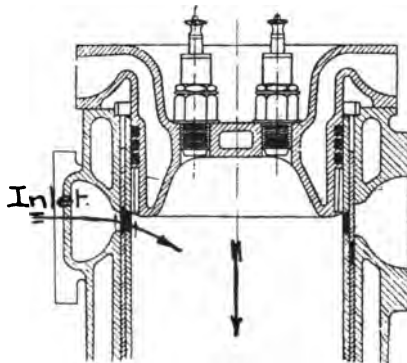


FIG. 128.—Suction Stroke.

thus the opening to the carburettor is closed during the next three strokes—namely, compression, working, and exhaust. During the suction, the compression, and the working

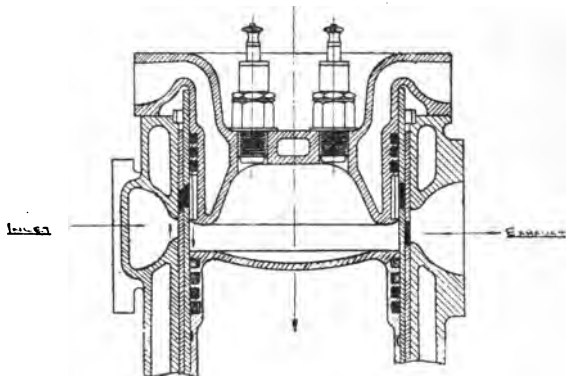


FIG. 129.—Compression and Working Strokes—all Ports Closed.

strokes the exhaust port at the right-hand side of the cylinder remains closed ; but the openings in the sleeves come opposite the port in the cylinder just before the end

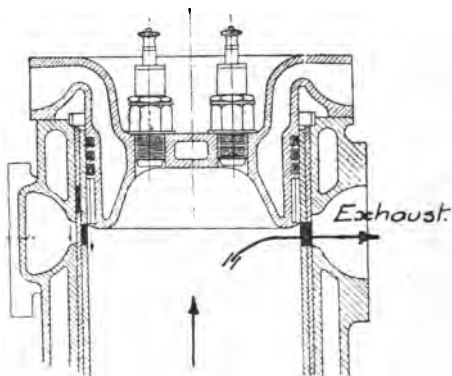


FIG. 130.—Exhaust Stroke.

of the working stroke, and it remains open during the whole of the fourth—or exhaust—stroke (see Fig. 130). Thus it is seen that the cycle of operations is the same as

in the commoner type of engine having tappet valves. Rings are fitted in the recess at the head of the cylinder, into which the sleeves slide, as well as in the piston, and so there is no loss of pressure during the compression and working strokes.

Advantages.—Having described the action of the engine and valves, it would be well to note the advantages claimed by the inventor for this type of valve action. These are—

1. Silence whether running light or under full load, due to there being no metal-to-metal striking, such as valves on their seats and cams on tappets.
2. Smoothness of running and absence of vibration.
3. Great flexibility and pulling power at low speeds.
4. Reliability, owing to fewness of parts.
5. Greater power for given size of cylinder than any other engine, due to higher compression made possible by the approximately spherical combustion chamber, and to the fact that the whole inside of the cylinder is machined.
6. Greater fuel economy under full load, also due to high compression.
7. Greater working endurance: that is, the ability to maintain full power without any falling off even after years of use.
8. Positiveness of valve action—in place of closing valves by springs, which may break, these are positively closed by the connecting-rod action.

Remarks.—These claims have been fairly well substantiated, though nowadays the increase in efficiency and reduction of noise are probably only a small percentage better in each case, because of the improvement in design—giving great economy and flexibility, together with less noise—in the case of the mushroom valve engine. These improvements have been to some extent due to the high attainments in the design of the sleeve valve engine. One or two points must be looked after very carefully in this engine. Due to the four working surfaces inside the cylinder, and to the fact that there are three thicknesses of metal (the two sleeves and the cylinder wall) between the hot gases and the cooling water, the lubrication must

be very thorough, otherwise the sleeves will overheat and crack. Care must also be taken that the oil pipes do not get choked up with dirt. And on account of the great care and accuracy required in construction, this engine is a very expensive one to make, and is only used in expensive cars.

Argyll Single Sleeve Valve Engine.—Another type of engine which uses sliding sleeves and ports in the cylinder walls for the inlet and outlet of the gases is that manufactured by the Argyll Motor Car Company. In this case, however, in place of having two sliding sleeves in each cylinder moving to and fro in a vertical straight line, all the necessary openings and closings of the ports have been obtained by a single sleeve, which has an oscillating motion about its axis as well as the usual up-and-down motion. The combination of these two motions gives a movement of the sleeve such that every point on it is travelling in a full ellipse—almost a circle.

Ports.—As in the case of the Knight double sleeve engine, the entry and exit of the gases are obtained by the holes in the sleeve coming opposite the ports in the cylinder walls, thus giving a straight passage out from or in to the cylinder for the gases. In order to obtain quick opening and closing of the passages, and in order that they may be open as long as possible, the ports have a somewhat fanciful design, which has been worked out after much experiment and trial.

General Arrangement.—Fig. 131 shows the general scheme of the engine; the piston, connecting rod, crank shaft, crank casing, etc., being much the same as in any other motor-car engine. To the right is seen a wheel (D) which is made to rotate by being in gear with another wheel (B), which in turn is driven by means of a silent chain from the crank shaft. There is a hole placed out of centre in the face of D, into which a sliding pin works, the other end of this pin being attached to lugs at the foot of the sleeve. As D rotates, the pin—and therefore the sleeve—describes a small circle, making half the number of revolutions of the engine. At this stage it should be

SLEEVE AND ROTARY VALVE ENGINES 149

noted that the cycle followed is the Otto four-stroke cycle ; and as the main events—suction, compression, working,

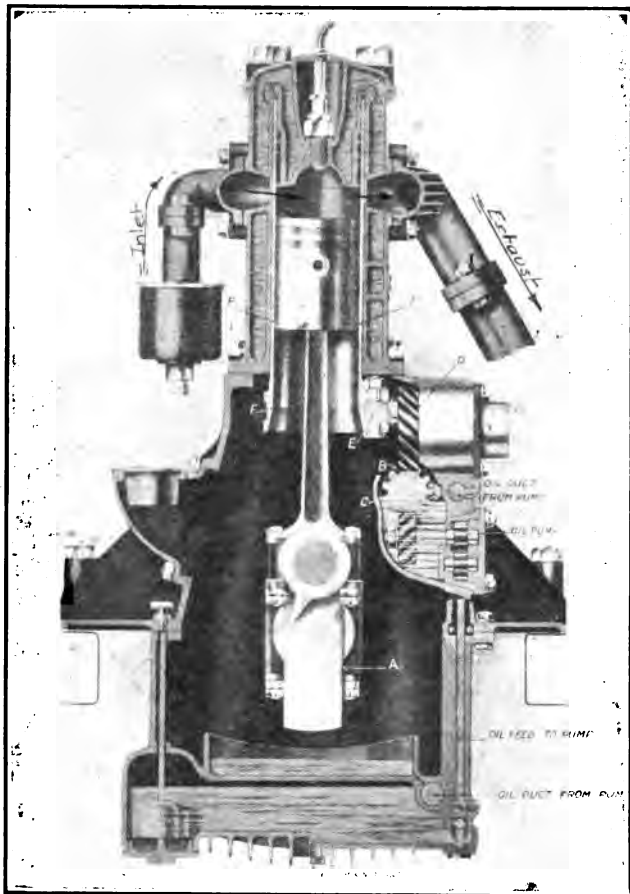


FIG. 131.—Argyll Single Sleeve Engine.

exhaust—occur only once in two revolutions—the reason for the half-speed of the sleeve is clearly seen.

Method of Action.—Without going too fully into

details, there are three ports for inlet in both the cylinder walls and in the sleeve, and also the same number for exhaust. It has been found convenient to run the two central ports into one on the sleeve, so that there are really only five openings in the sleeve; but they have the effectiveness of six, one being used both for inlet and exhaust. Then, during the suction stroke the three suction ports in the sleeve are made to come opposite the three suction ports in the walls of the cylinder by the movement of the sleeve, and these being opposite the carburettor

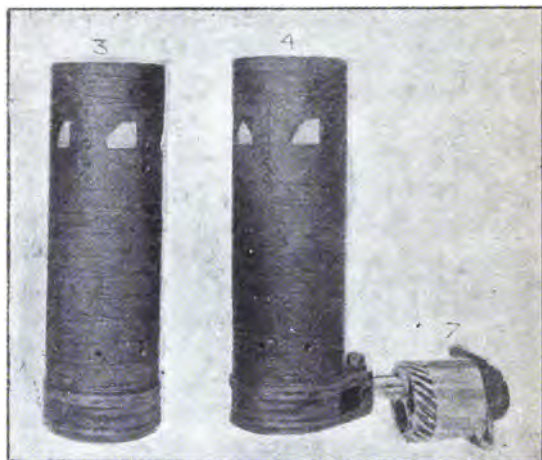


FIG. 132.—Showing Sleeves and Connection to Driving Wheel.

pipe the piston descending sucks in the charge of petrol and air in the ordinary way. During the next two strokes—compression and working—the ports in the sleeve slide up into the circular recess at the top of the cylinder (H), and thus there is neither entry nor exit of gases. Near the end of the working stroke the exhaust ports come into register and remain open until the end of the exhaust stroke.

Gains.—The advantages of the single sleeve engine are similar to those of the double sleeve engine, and it has the further advantage of considerable simplification by having one sleeve in place of two. Other points are that the

circular motion of the sleeve has the effect of distributing the lubricating oil very thoroughly ; and also, in place of the sleeve having to come to rest at the top and bottom of the stroke to reverse its motion, the single sleeve is always moving. Recent trials at Brooklands, in which this car broke a number of long-distance world's records, show that it can keep up high speeds and develop high power for a long time. Whether sleeve valve engines will totally displace poppet or mushroom valve engines is problematical, especially where the cheap car is concerned ; but they have proved themselves to be very efficient sweet-running engines, and at least a dozen well-known makers are now using them on their cars.

Details of Valve Action.—Whilst the novice need not worry about the exact method of opening and closing of the ports, so long as he can grasp the main idea that they are controlled in such a way by the mechanism that they open and close at the proper time, there may be some who would like to go a little deeper ; and it is for their benefit that what follows is written. Fig. 133 shows the inner wall of the cylinder and the outer wall of the sleeve, rolled out flat, and the one put on top of the other in the positions they would occupy when in place on the engine. The sleeve has the motion shown by the elliptical curves in the centre of the figures. Part 1 of the diagram shows the ports on the sleeve just about to come into register with the inlet ports in the cylinder, as shown at A ; 2 shows them in register, the black space representing the hole right through the cylinder wall and sleeve to the carburettor ; 4 and 5 show all ports closed, but in 5 the other set of ports—the exhaust ports—are just about to come opposite each other, the sleeve now travelling in direction B ; 6 shows the ports when this has happened, the blackened parts representing the exit from the cylinder to the exhaust pipe, and so completing the cycle.

Rotary Valve Engines.—Since the earliest times workers in brass and iron have been endeavouring to overcome the difficulties and disadvantages connected with the conversion of the to-and-fro or reciprocating motion to a rotary motion. Reciprocating motion was originally the basis of all prime movers, though in later days the advent

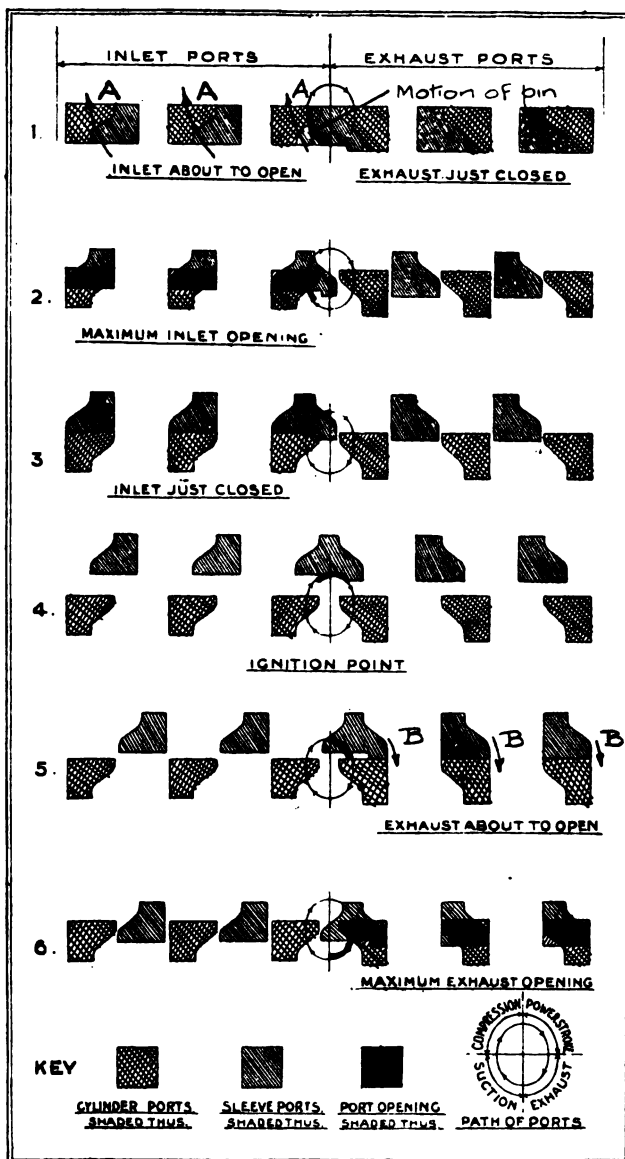


FIG. 133.

of the electric motor and of turbine machinery has given us generators of energy whose motions are wholly rotating. Perhaps the almost universal use of pistons for power development has made engineers rather prone, when a controlling motion is desired—such as the ingoing or outgoing of steam or gas in engine cylinders, to go back to their old favourite. But every student of mechanism knows that reciprocating motion is wasteful ; and, due to the reversal of the direction of travel in the rods, etc., large stresses are set up and difficulty is experienced in keeping the joints and pins tight. Why engineers use it can only be explained by the tendency that exists even in these advanced days to follow what has been usual in the past. For example, there is no reason why this up-and-down motion should have become almost universal for the valve action in petrol engines. True, now that thousands of expert engineers have been working on this design of valve for the last fifteen years it has become almost perfect in its action when new, but it still has many disadvantages when worn.

Rotating Valves.—Newer ideas have been coming forward lately, and engineers have invented a number of methods of controlling the gases without the use of reciprocating pieces and the necessary cams. In place of these some form of rotation has been employed, and in several cases the new principle has been used by motor car engine builders with good results. As in the poppet valve and sleeve valve engines, the Otto or four-stroke cycle is followed ; and as in the sleeve valve engine, the gases are admitted and expelled through a port or opening in the walls of the cylinder. To come to details. Alongside the cylinder of the petrol engines under discussion is cast another and somewhat smaller cylinder in which a piston rotates but does not move parallel to its driving spindle. At certain times in its rotation a part cut out of the piston allows the inlet pipe from the carburettor to connect up to the port or opening in the cylinder wall ; at other times the exhaust pipe is connected up. During nearly one half of its rotation—that is, during compression and working strokes—the piston or rotating valve presents a solid face to the port in the cylinder.

The Itala Engine.—Fig. 134 shows diagrammatically one engine of this type, namely, the Itala engine, in which the spindle driving the rotary valve is rotated by means of a worm and worm wheel in the crank chamber. This vertical shaft driving the piston which forms the valve would rotate at one half engine-speed if there were a separate valve for each cylinder, because in the four-stroke cycle each of the actions such as suction, compression, etc., only occurs at intervals of two revolutions of the engine. In order to simplify the engine, however, and to give less machining, each valve is made to serve two cylinders—that is, one half of one revolution, or 180 degrees, instead

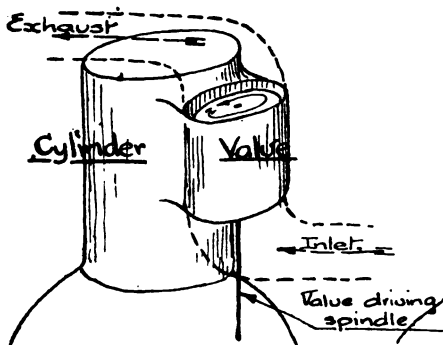


FIG. 134.—Diagram showing rotary valve.

of one whole revolution or 360 degrees of the valve's motion, is used for one cylinder, the other half being used for the second cylinder, so that the valve only travels at one quarter the speed of the engine. This arrangement also makes each side of the rotating piston-valve equal in every way, thus eliminating the chance of the valve causing excessive vibration due to want of balance.

Details of Valve Action.—Looking at Fig. 135, the general details of the engine and valve and the method of driving are seen. What corresponds to the cam shaft in an ordinary engine is driven at engine speed, and gears through a worm and worm wheel whose reduction is 4 to 1 to the vertical valve shaft.

Suction.—In the position shown the piston has just commenced to descend on its suction stroke, drawing into the cylinder the necessary charge of gas and air as shown by the arrow. When the piston has reached the bottom of the stroke the valve has rotated into such a position that

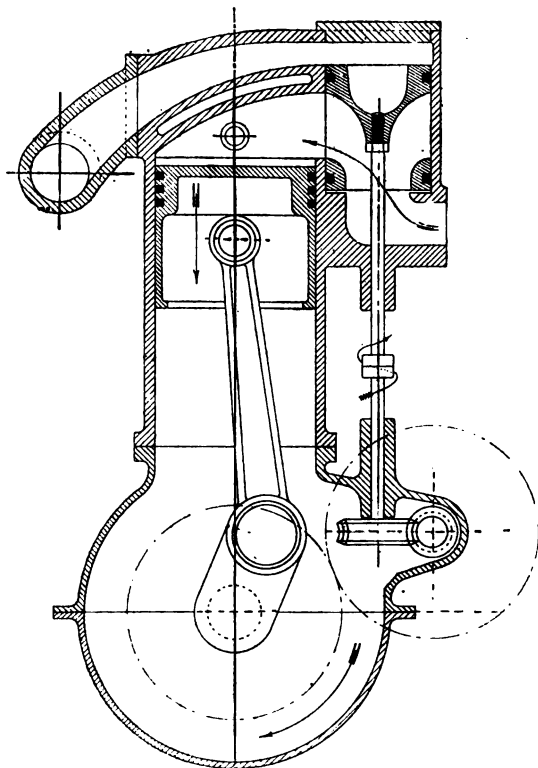


FIG. 135.—Suction.

it presents a blank wall to the opening in the cylinder, as shown in Fig. 136. Compression then commences considerably before the end of the working stroke takes place, the blank wall of the valve still being presented to the cylinder opening.

Exhaust.—As in an ordinary poppet valve engine, exhaust commences considerably before the end of the working stroke, the rotary valve having turned round sufficiently to present another opening to the cylinder. The exhaust gases, as shown by the arrow in Fig. 136

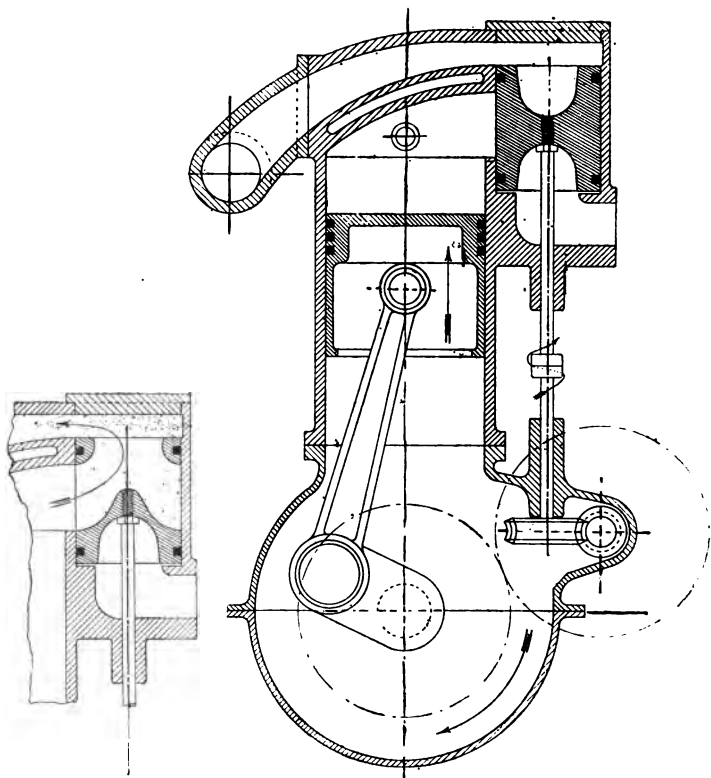


FIG. 136.—Compression.

(small diagram), travel through a pipe over the top of the cylinder, and so to a common pipe which leads to the silencer. Each valve—in a four-cylinder engine there are two—has two complete sets of ports (namely, two inlet ports and two exhaust ports), and so controls two cylinders.

Cooling.—As in the ordinary engine, the cylinders and valve pockets are water cooled, and by an ingenious arrangement the rotating valve has water-cooling passages cast in it through which there is a constant flow of cooling water, which prevents unequal temperatures and precludes the possibility of distortion that would result in bad fitting of the rotating valve and so cause leakage and loss of compression, and might even result in the binding of the valve. A point to be noted is that the two valves on an engine rotate in opposite directions, thus balancing the arrangement as a whole and causing the thrust due to the worm-gear drive in the one valve to be balanced by that of the second drive. To prevent the explosion pressures driving the rotating valve against the walls of its casing, so causing excessive wear, arrangements are made so that by means of a small bypass the pressure is allowed to act on the far side of the valve as well, thus equalising the two sides of the valve. As in the sleeve valve engines, the highest quality of workmanship is required to get the best results, and the Itala car is not a cheap car, but represents the very best workmanship and material which can be produced. When first put on the road this car was watched with considerable interest by the experts, but now its sweet and efficient running is taken as a matter of course.

Other Types.—Other types of rotary valve engines are the Reynolds rotary valve engine (in which there is a simple disc with an aperture in it which comes into register with the gas passages in the top of the cylinder at the proper time, the disc being driven at half engine-speed) and the Mead rotary valve motors on somewhat similar lines.

THE END

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